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DURATION AND THE TEMPORAL JUDGMENT[1]

By Josephine Nash Curtis

Introduction

The tendency of modern text-books of psychology has been to abandon the concept of duration as a derived character of mental processes or as a relation of psychical elements, and to adopt in its place the view that duration is an attribute of sensation co-ordinate with quality and intensity. The basis for this change has been in the main logical and theoretical; but the question must arise whether we can obtain any introspective evidence for the ultimate character of duration. There are, of course, two possible sources of such evidence: incidental references to the matter in the experimental literature, particularly that of the 'time-sense'; and introspective data obtained by further investigation which has, as the older experiments had not, the question of the ultimate character of duration as its goal.

Study of the literature of the subject proved less fruitful than might at first be imagined.[2] The first of the experimental studies to discuss the nature of duration is that of Mach,[3] who says that all sensations

[1] From the Psychological Laboratory of Cornell University.

[2] The writer read, beside the references given in E. B. Titchener, Experimental Psychology, vol. II, part ii, 1905, 394-400, the more recent work such as that of Benussi, Yerkes and Urban, Urban, Overstreet, Rageot, Burrow, Lobsien, Peres, Schmied-Kowarsik, Brewer, Gildmeister, Stratton, Wallin, Biehle, Dunlap, Pitkin, and others listed in the current bibliographies, beside many articles which proved to be concerned with the philosophical, musical, or physiological, rather than with the psychological aspect of our problem.

[3] E. Mach, *Wiener Sitzungsber.*, math.-naturw. Cl., 51, Abth. 2, 1865, 133; *Die Analyse der Empfindungen*, 1902, 185ff.

Printed in Germany.

are accompanied by the time-sense. He attempts to reduce this 'time-sense' to attention, and places himself on the side of those who believe the temporal element is not an ultimate datum. In his later writings,[4] Mach upholds a definitely genetic theory of time, and so denies that duration may be an attribute of sensation. Vierordt[5] remarks that "the operations whereby we gradually come to a concept of the temporal and the spatial, and which allow us, even compel us, to add to our sensations the measure of time and space are completely hidden from us," and that "the spatial and temporal dimensions of sensory stimuli come, so to speak, immediately into our consciousness." Fechner[6] maintains that "a longer time between two impressions appears longer not on account of its abstract, empty, physical size, but on account of the greater sum of psychophysical activity which it includes," thus indicating that duration is to be considered neither as mere physical duration, nor as an immediately given character of mental process.

Münsterberg,[7] after many experiments performed upon himself, concludes that our time sense is manifested in a hundred forms, but that all these forms have strain sensation as basis. For short intervals he finds rhythmic tensions of the muscles about the sense organs the basis of judgment. For all intervals, however, the processes accompanying respiration primarily determine our estimation of time. Nichols[8] concludes that duration is an attribute of every sensation and every image, and that this attribute is the ultimate and essential datum of time, although his conclusion seems little connected with his experimental work. He distinguishes between perception and apperception of time.[9] Time, for him, is apperceived "when any process of duration occupies the focus of attention, is the object of association, and calls up durative associations," and it is only as associated ideas of length that we have the muscular tensions, dermal stretchings, joint pullings, etc., that have been taken by others to be the sole components of the perception of time. Münsterberg and Wylie[10] confirm Münsterberg's earlier work by finding that the "subjective measure for time lengths seems to lie in sensations peripherally aroused by muscular activity, especially by the strains and relaxations which take place in the various groups of muscles conditioned upon bodily reactions to changing intensities of stimuli. Such reactions occur in the functions of breathing, in the voluntary movements of the eyes, limbs, etc. Stevens[11] also denies the immediacy of temporal judgments. He writes "our judgment of time is mediate, depending upon organic processes, of which change in blood volume is one of the more important." Aliotta[12] names rhythm and expectation as two criteria in judging times, and says that the former is more effective for short times, the latter for long, but he

[4] *Erkenntnis und Irrtum, Skizzen zur Psychologie der Forschung*, 1906, 423ff.

[5] K. Vierordt, *Der Zeitsinn nach Versuchen*, 1868, 13f.

[6] G. T. Fechner, *Abh. d. kgl. sächs. Ges. d. Wiss.*, Math.-phy. Cl., 13, 1884, 7.

[7] H. Münsterberg, *Beitrage zur experimentellen Psychologie*, II, 1889, 20.

[8] H. Nichols, *Am. Jour. of Psych.*, 4, 1891, 85.

[9] *Op. cit.*, 92ff.

[10] H. Münsterberg and A. R. T. Wylie, *Psych. Rev.*, 1, 1894, 52.

[11] H. C. Stevens, *Am. Journ. of Psych.*, 13, 1902, 26.

[12] Aliotta, R., Instituto di Stud. sup. di Firenze, *Ricerche di Psicologia*, 1, 1905, 1ff.

does not go into detail. Up to this point the writers, with the exception of Vierordt and Nichols, have insisted on the secondary character of temporal judgments. Meumann[13] now carries out a long series of experiments, the result of which attests the immediate character of these judgments, and apparently the ultimate character of duration. He works under Wundt's direction, and the system in terms of which he naturally expresses his ideas makes duration a creation of the synthesis of sensation with feelings of expectation and fulfillment. Nevertheless he writes: "According to my notion *every* psychical process is measure of time in the sense that every psychical process brings to consciousness, through its qualitative and intensive *changes,* temporal relations of *succession;* and through its relatively *unchanged persistence* in respect to quality and intensity, temporal relations of *duration.* . . . Whether or not all psychical processes can bring temporal relations to consciousness in an equally *accurate,* and—for our apprehension— an equally *convenient* way, or whether we perhaps *favor* . . . certain psychical processes to make the temporal relations clear, just as we depend on the eye for the estimation of space, although we could use the hand or arm, is quite another question."[14] He goes on to say: "I presuppose as a final fact of experience, incapable of further discussion, that the processes of our consciousness, of our inner perception, are given constantly at the same time as processes of a *temporal* nature, i. e., as standing in a temporal relation, and that we can bring these temporal relations of our conscious processes to consciousness in relative abstraction, just as we can perceive relations of intensity in comparative isolation, although they are always there merely as the intensive steps of certain qualities. I shall further take it for granted that this temporal state, which is brought to consciousness in relative isolation, can be made the unique object of a judgment."[15] He then distinguishes between mediate and immediate judgments of time, and urges that both kinds occur. From the observations of his subjects, as well as from his own more or less theoretical conclusions, he argues for the immediacy of temporal judgments. "Since it is so difficult to compare two differently filled times, the observers easily hit upon artificial aids to judgment, thinking thereby to make the judgment easier. This course, however, I always prohibited, and requested a *purely passive resignation to the impression of the interval of time.* It is interesting to note that in the course of the experiment all such aids as beating time, nodding the head, respiratory movements, innervation of the larynx, rhythmical counting, and so on very soon disappeared. They were recognized by the observers as disturbances, rather than as aids." Meumann, then, states definitely his belief in the immediate nature of the judgment of time, and he seems to imply also that duration is an ultimate datum of time. He speaks, to be sure, of 'temporal relations,' but quite as he might speak, if he liked, of 'intensive relations' rather than of intensity. His comparison of 'temporal relations' with intensity, and his approval of Nichols' statement that duration is an irreducible attribute of sensation (when Meumann quotes Nichols (*ibid.,* 8, 1892, 503) he speaks of the "elementary, irreducible time experience," though Nichols himself says "attribute of every sensation and every image") seem to place Meumann in the group of those believing in the ultimate nature of duration.

[13] E. Meumann, *Phil. Stud.,* 8, 1892, 450ff.

[14] *Op. cit.,* 504.

[15] *Phil. Stud.,* 12, 1896, 143.

Now, again, denial of the final nature of duration appears. Schumann[16] says: "A secondary impression of suspense of expectation is noticed before every impression, though I can not determine on the basis of introspection whether it consists of strain sensations aroused by muscular contractions, or of internally aroused feeling of strain. The secondary impressions of expectation and surprise are really the psychic contents on which we rely in comparing short times." Elsewhere,[17] however, he acknowledges that there may be another psychical element present in time-comparison which has escaped notice, and finally[18] he concludes that although accurate and subjectively certain judgments are always mediate, the question of whether we can ever judge two intervals immediately "is not wholly simple to decide." Quandt[19] is not definite as to the true nature of the judgment, but asserts that "estimation by secondary peripheral accompaniments on which Münsterberg has sought in greater part to base his theory of time-perception may on no account be considered conclusive." Katz'[20] observers find that in general certain strain sensations seem to be essential to the experience of time. Katz finds judgments like those of Schumann in which the observer expects the second member to equal the first and judges whether this member stops too soon, at the proper time, or too late to equal the first, and he also finds judgments of absolute impression. Further discussions of these forms of judgment and of Katz' criticism of Meumann's passive instructions will be given later in this paper. Alvord and Searle[21] found that in general judgments are made on the basis of strain and relaxation, imagined movements, auditory rhythm and the spontaneous occurrence of auditory images of the stimulus, although some intervals were said by one observer to be judged 'mechanically.' Schultze[22] speaks of the spatial, intensive, and qualitative characters of "experience and mental structures" and concludes that temporal extent is a fourth such character which cannot be reduced to the others. Moede[23] instructs his observers to give "free" judgments. From their reports he finds two basic constituents (*Grundbestandteile*)[24] of every temporal consciousness: duration and progression (Fliessen). "At one time the observer may give himself up to temporal course and is then taken up with the progression of the quality. At another time he may lift himself out of the level of the continuum and look out from a higher, as it were resting, point of view. In the one case he is like the boat in the stream, which is carried on by the waves, whereas in the other he is like the viaduct through which the stream of temporal quality runs. The natural set is a mixture of the extremes, which can best be described as *progressing duration.*"

Let us now see what arguments are urged as showing that duration cannot be an original character of sensation. There

[16] F. Schumann, *Zeits. f. Psychol.*, 4, 1892, 2.
[17] *Ibid.*, 17, 1898, 113.
[18] *Ibid.*, 125.
[19] J. Quandt, *Psych. Stud.*, 1, 1906, 153.
[20] D. Katz, *Zeits. f. Psychol.*, 42, 1906, 302ff.
[21] E. A. Alvord and H. E. Searle, *Am. Journ. of Psych.*, 18, 1907, 177.
[22] F. E. O. Schultze, *Arch. f. d. ges. Psych.*, 13, 1908, 275.
[23] W. Moede, *Psych. Stud.*, 8, 1912-13, 327.
[24] *Ibid.*, 366.

are two main arguments against the attributive character of duration. The first is the argument of the Wundtian school, —the argument from relativity. Statements of duration, it is said, can only be relative. Any temporal experience whatever implies logically a relation to other experiences; to be durative at all, experience must be apprehended as longer than, shorter than, or equal to another, before or after or simultaneous with another; and an experience which merely lasts, but does not last for a definite time, or at a definite time, is unthinkable. Psychologically, this objection takes the form of stating that duration is a perception, the character of which has developed from the interplay upon sensation of other processes, such as strain sensations or the various feelings which are connected with the sensation in experience. Duration, accordingly, must be regarded not as an original character, an attribute of sensation, but as the final product of a creative synthesis. Such an objection can hardly be met by direct introspection, by observation pure and simple. But if we find cases in which there appears an approximation to a duration which introspectively is neither longer, shorter, nor equal with regard to another, we shall go some way toward meeting the logical argument.

The second argument against the attributive character of duration makes a more direct appeal to introspection.[25] "Suppose, then, that we allow sensations a psychic duration, as distinguished from objective duration. Whatever the character of this consciousness, it must be contained in the 'psychic present,' else surely we are no longer dealing with a single element. Within this limit, then, sensations must be capable of differing in subjective duration. But can the 'psychic present' have subjective duration? . . . The psychic moments follow each other; they have no duration. The perception of duration is the perception of two or three such successive moments having similar contents. . . . While it seems absurd to treat their objective duration as one of the attributes of sensations, yet the only other way to maintain that they have a temporal attribute is to hold that the subjective present does possess subjective duration, a view which I think introspection does not confirm." The proving or disproving of the attributive character of duration, then, according to this view, lies in the introspective question whether a sensation may be perceived as duration within the limits of the conscious present.

From the results of our experimental work we shall en-

[25] M. F. Washburn, *Psych. Rev.*, 10, 1903, 421ff.

deavor to draw two main conclusions. First, that the results of previous investigations are not as contradictory as they at first seem; secondly, that the two chief arguments against the ultimate nature of duration are not supported by experimental observation.

Experimental Investigation

Purpose: As already stated, the main object of this series of experiments was to discover what evidence introspective analysis offers for the attributive nature of duration.

Stimuli: Following the example of many earlier investigators, we used auditory stimuli throughout the first groups of experiments.

Apparatus: The length of the stimuli was controlled by a device attached to the Leipsic 'time sense' apparatus.[26]

This device consisted of four aluminum arms clamped to the central shaft of the rotating disc, and so arranged that, when two of the Leipsic lever-contacts were in position, the first arm moved the one lever of the first contact the second arm the other lever. The third and fourth arms acted similarly upon the second contact. In order that a given pair of arms should not act upon both contacts, it was necessary merely to raise one contact slightly and to raise the corresponding arms. By this arrangement the first two arms moved the first contact and passed under the second; the other pair moved the second contact similarly, but passed over the first without touching. In order to prevent the single member of a pair of arms from moving both levers of a contact, a small copper post was erected upon one lever of each contact, a short distance from the point of the lever, and the corresponding arm raised slightly and given an appropriate length. With such arrangements, when the Baltzar kymograph, to which the whole apparatus was attached, revolved, the disc of the time apparatus revolved also and each arm moved only one lever of one contact. Further advantage of the aluminum arms lay in the fact that they were so attached to the shaft that either the first arm or the fourth arm might be shifted in position without altering the positions of the other three. It was thus possible to vary the length of the first, of the second, or of both members of any pair of stimuli. The sound itself was given by an electrically driven 254 v. d. tuning fork. The fork was placed in a sound-proof box with its resonator opposite a telephone transmitter. The transmitter and a dry-cell were connected with the primary coil of an inductorium; the contacts of our apparatus and two telephone receivers, one for experimenter and one for observer, were connected with the secondary coil. A switch was introduced in such a way that the experimenter could hear the sound in the receiver whenever the kymograph revolved, while the observer heard the sounds only when the switch was closed. The tone which the observer heard was of moderate intensity, and was without unpleasant buzzing of the receiver. At first the kymograph was tested

[26] A diagram and detailed description of the 'time sense' apparatus may be found in W. Wundt, *Physiologische Psychologie*, 2, 1893, 424, and in Meumann, *Phil. Stud.*, 9, 1894, 270.

every two or three weeks; but after a number of trials it was found that the average deviation for ten readings was never more than .02 sec.; so that in the later work the apparatus was tested only at the beginning of a new group of experiments. A series of readings taken to find with how great accuracy the experimenter usually set the instrument showed a mean deviation of .03 sec., The observer was placed in a quiet dark room and heard the sounds through a telephone receiver attached to his left ear. This dark room and the room of the experimenter were connected by a system of electric bells, which enabled warning signals and reports of judgment to be sent from the one room to the other, as well as by a speaking tube through which the observer gave his introspections.

Method: The psychophysical method used in all the experiments was that of constant stimuli. The series were from 12 to 16 members in length, and in all except the first group (in which irregular steps were used) the steps were of .1 sec.

General procedure: The experimenter started the kymograph, allowed it to rotate twice to attain its maximal speed, rang two warning bells[27] 4 sec. and 2 sec., respectively, before the first sound was to be heard, closed the switch, and opened it again after the second sound had been given. The kymograph was then stopped, the judgment which the observer had rung on his bell was recorded, a new setting was made, and the procedure was repeated. The time from the ringing of a judgment to the first warning bell for the next pair of stimuli was approximately 45 sec.

Treatment of results: Our chief interest lay in the introspections, and no claim is made for the significance of the numerical results. There are in general entirely too few cases in any group to have any importance, and no attempt has been made to make the quantitative series complete, i. e., to compensate for time-error, etc. All the limens have been calculated by the method of right and wrong cases. In the mathematical work, Urban's table and Crelle's three-place multiplication tables were used. All our results are recorded in the number of degrees on the instrument (50°=1 sec).

Group 1

This group consists of preliminary experiments, whose general purpose was to find what secondary criteria were most likely to come into the judgment of time-intervals even when the observers were warned against such criteria, and to obtain hints for the direction of further work. Two continuous sounds were given with an interval between them of 1.5 sec. Three standard times were used: 50°, 75° and 100°, given in both time orders.[28]

[27] Observers Bo and D, and later Gou and W preferred one warning bell and there seemed no reason for insisting on two being given.

[28] Only one contact was used on the apparatus.

Observers: Dr. E. G. Boring (Bo), instructor in psychology, observed 7 hours; Mr. F. L. Dimmick (D), graduate student, 15 hours; Dr. W. S. Foster (F), instructor in psychology, 20 hours; and Dr. M. E. Goudge (Gou), graduate student, 30 hours. Bo, F, and Gou were highly practised observers; D was relatively inexperienced.

Instructions to observers: "About two seconds after the second warning signal you will hear two sounds in the telephone receiver. You are to judge whether the second of these is longer than, equal to, or shorter than the first. Give your judgment with the push-button as follows: shorter than, 1 ring; equal to, 2 rings; greater than, 3 rings. If it should be necessary to give a doubtful judgment, give two short rings after the rings for the judgment. You are warned to be on the lookout for secondary criteria, and especially not to get in the habit of judging by some secondary criterion."

Results: The quantitative results of this group are so scanty as to be wholly without significance.

From the introspections[29] we find, as Meumann did, that at first all sorts of 'artificial' aids are employed in making the judgment.

The most commonly used aid is ***kinaesthesis*** in some of its manifold forms. Bo reports at first that "chest kinaesthesis has a great deal to do with it. I get a very definite muscular feeling as if I were pressing down inside my chest. It is quite independent of breathing; is probably imaginary. These processes carry the course of the sound; by that I mean that during the sounding of the second member, I assume the attitude of making the noise voluntarily myself, i. e., I screw this chest pressure down as if it were making the noise." At a later date Bo says: "There always seems to be relevant kinaesthesis in the body somewhere."

At first D, also, reports kinaesthesis: "Carried the first over sort of kinaesthetically," "sort of hummed along with both tones, then decided whether the second felt longer, shorter, or equal," and "judgment passed according to the kinaesthesis."

Gou used in general eye-kinaesthesis. She reports: "images representing the length of the two members, consisting for the most part of kinaesthetic sensations in the eyes, meaning 'length of tone as represented by a line which I couldn't see, but which I localised.'"

Early in the experiments F stated that "the sound comes, is attended to clearly, the head goes forward slowly just a bit, keeps moving forward all the time the sound is there, at the end it comes back with a sudden jerk. With the second sound, the head goes forward again just the same sort of way and snaps back at the end," and "when the second sound had gone on as long as the first, which I think also means, when the head movement had gone on as long and as far as

[29] The excerpts from the introspections which are quoted are, of course, very scanty, but they are representative. The complete introspections are left in the Cornell psychological laboratory.

the first head-movement. . . ." After some practice, F reports that the body and head kinaesthesis disappeared.

When warned that the use of kinaesthesis might be interpreted as constant reliance on particular secondary criteria, D[80] reports that the kinaesthesis is not necessary for the judgment: "don't think there was any kinaesthesis here, though the judgment seemed just as easy to make."

Special instructions were given to Gou to do away with kinaesthesis entirely, but this proved to be impossible. She says: "I can't just have tone sensation and nothing else in consciousness unless I give myself up passively, and then I am not judging anything."

Bo observed for so short a time that it is impossible to say whether with further practice he would have discarded kinaesthesis, or whether he would have been able to do so under instruction.

All observers report at times supplementary "representations," or "formulations," of the sounds. In general these are most frequent in the first stages of the experiments, and when there is some doubt about the judgment. They usually appear either between the members or after the second member. They are found in various sense-departments, may arise involuntarily or be called up voluntarily, and may be either detailed or abbreviated.

Bo says: "I formulated the length of the first member just about at its end. By formulation I mean that there seems to be some way in which the length of the member gets itself represented. I don't think this representation is a temporal course; if it is, it is a very much abbreviated one. I can't describe the thing which carries the length of that member, but I think it is like kinaesthesis"; "the formulation involved auditory imagery;" "the formulation is the whole sound in a nut-shell (running off in perhaps 1/50 of the time of the member), temporal course and all; some chest kinaesthesis, some ear kinaesthesis, and some auditory image." Bo also speaks of "visualising the members as running along together."

D speaks of "visualising the two sounds as a couple of gray streaks," "carrying the first sound over kinaesthetically," and one day, "visual images seem to mean the sound, but I don't think I judged the lengths of the sound by them."

F reports various kinds of representations: "went over the whole thing in imagery (visual to a great extent) in some short-hand way"; "the going over in imagery has much more kinaesthesis in the throat than much of my ordinary imagery of sounds"; "went over the whole experiment in image, mostly auditory, which I don't think took as long as the actual experiment"; "intentionally ideated the thing schematically, both auditorily and visually"; "there was a representation which, as nearly as I can tell, was an auditory image of the end of the tone over again with some realization that there was more ahead of it and how much more there was ahead of it. What that realization was I simply don't know;" and "this time it was a real representation, sometimes it is symbolic."

Gou speaks of a "fixing" of the duration of the first member in the interval, "by means of kinaesthetic terms; i. e., kinaesthetic sensations in the eye-region and trunk of the same kind as had accompanied

[80] D's later introspections, however, lay such stress upon the kinaesthetic and organic accompaniments of the comparison, that it seems possible that in these early experiments, before he attained practice in introspection, he may have overlooked vague or weak strains, etc., which he noticed later.

the first member were present and meant 'first member was just so long'"; "very vague visual images representing the length of the two members"; "sometimes I choose between comparing quickly in schematic form and, as it were, living the experience over again"; "some kind of a representation of the member in scrappy and schematic form, in a nut-shell, one might say."[31]

In the method of forming the judgment we find several tendencies which agree more or less with the findings of earlier investigators. The most common tendency is expressed sometimes as "expecting the second to be just like the first" and sometimes as "laying the first off on the second."

Bo says: "It was almost as if the second itself meant the first, as if there were identity"; "I reformulated the first upon the second as a background. . . . I held the formulation as a sort of a static kinaesthetic thing with kinaesthetic kinks in it on the background of the smooth second tone. Then I cut loose from the formulation and anticipated the end of the second member. This anticipation was a sort of heightening of the kinaesthetic complex in which one kink became especially intense and in which reference forward was visual image or eye-movement (I don't know which). It was as if out of the complex I got a cue relevant to the end, as if I were set ready to 'go off'; the muscular feeling of an incipient action. The tone ran on, and just as it stopped the kinaesthesis changed as if I had 'gone off.' Then a moment's hesitation, then retrospection, mostly visual, of the tone and the kinaesthesis snapping off together, and the judgment of equality." "Some time after the second member had started, I voluntarily recalled the first member and started it running along with the second. Was slightly surprised to find they fitted although they hadn't begun at the same time, because I thought the formulation had to run a course that ran along with the second member and couldn't be started late."

D speaks of "carrying the first member over to the second largely as a kinaesthetic image in my throat" "this time the sounds seemed very much alike, seemed like the same one over again."

F reports: "In some way I identified the second sound with the first;" "I attend to the second tone as if it were the first tone being repeated. In a certain sense I expect the second tone to be the same as the first. . . . This attending to the second the same way I attend to the first, this expecting the second to be the same as the first, this taking the second tone as a repetition of the first, means that the end of the second tone is somehow expected to come at a definite place ahead"; "the second is apprehended as a repetition of the first. There seems to be no conscious process to carry the meaning that it is a repetition, it merely is a repetition."

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[31] These reports of 'short-cut" images and sensations which adequately represented the time-intervals are in direct contradiction to Nichols, who writes (*op. cit.*, 90): "I think that every one who will observe his own mental processes when he seeks to measure or to realise the length of any durating sensation or its representation in memory will easily observe that he never fully perceives or remembers the length instantly or even approximately so; unless, of course, the duration is itself instantaneous or approximately so. On the other hand, I think anyone will easily convince himself that *fully* to perceive or to remember the length of its representation, these representations must stretch themselves out through an equal process and lapse of time as did their original occurrence."

Gou did not state definitely that she ever took the second as a repetition of the first or that she "laid off" the first on the second.

A second type of judgment that began to appear near the end of this group of experiments was that called variously "automatic," "immediate," or sometimes "unconscious."

Even during the short time for which Bo observed he reports once that the judgment was "almost automatic," and several times that the ringing of the judgment was "unusually automatic, as I didn't think definitely of giving three rings until I was actually hearing the second."

D reports a number of times: "I knew it was shorter the minute the sound stopped"; "that was almost automatic, as I was thinking about something else"; "the deciding seems to me to be unconscious"; "I just hear the sounds and make the judgments without knowing why or how."

F gives many of these judgments: "end of the sound and start back of the body came at the same time. Automatically pushed the button twice"; "judgment touched off automatically, don't get internal speech or anything like that, just press button"; "automatically reacted with three very quick and strong pressures and was surprised. Haven't any idea why I pressed the button three times. Judgment was entirely automatic. Nothing in consciousness so far as I can see that represents the judgment or the judging. The mere longer duration of the second tone, without any consciousness that it was longer, seemed to touch off the reaction."

Gou reports continually: "immediately when the tone had ceased the judgment 'equal' appeared"; "immediate judgment carried by kinaesthesis in the throat"; "immediately at the end of the perception of the second member came an attitude meaning 'shorter' and I then reacted." When special instructions were given to Gou to "institute a direct comparison and not rely on immediate judgments," in an attempt to discover whether under such instructions her method would be similar to that of the other observers, she seems merely to add to her former method by supplementing the immediate judgment by a representation of each member, which, in turn, is followed by what she calls a second "immediate" judgment.

Apart from the introspections dealing directly with the process of judgment, we find many other statements which in reality bear more directly on the question of the nature of duration than those which have been quoted. Particularly to be noted are those which deal with the two dimensions of time. Titchener[32] has written: "To the author, it seems that psychological time is . . . a surface, a bidimensional manifold, and that its two dimensions are simultaneity and succession."

In the introspections of Bo, the following is found: "I should say that the thing has perhaps what one might call duration but no temporal course. It may be something like Titchener's transverse temporal dimension. I think that I should say it all came within a single conscious present"; "I want until further notice to use the words duration and durative to mean a sort of static, non-spatial extension. This is my notion of the other dimension in bidimensional time, and it is also my notion of the measure within a conscious present. It doesn't move along although it may get bigger"; "the first tone was unitary, by which I mean it was all within a single conscious present."

F says: "attention is on the sound as a whole; i. e., the sound is

[32] E. B. Titchener, *A Text-book of Psychology*, 1910, 340.

all one thing; even though it has a course, the sound is nevertheless all there at once"; "in some sense or other the first sound did stay in consciousness all through the experiment. I can't say that it persists as a memory after-image, can't say definitely that it didn't repeat itself. It certainly did not become longer. (Just as a visual image may stay in consciousness with its qualitative and extensive attributes unchanged, so this sound, which is primarily a durative thing, stays without change in its durativeness?)"; "all I hear while the first stimulus is going on is one thing; in spite of the fact that the tone goes on and changes, it still is there simultaneously in some sense"; "the whole member is usually in one conscious present."

Gou gives a similar notion of the second aspect of time when she says "there seemed to be a holding over of the accompaniments of the auditory sensations, which may have been a sort of echo of the tone, or sometimes, a prolonging of the tone; this prolongation does not mean that the duration of the previous tone is made any longer, but just that I have hold of it, as it were."

The 'longitudinal' dimension of time is most clearly stated by F who repeatedly says that the tone "goes forward," "has a course"; "I do not mean that the sound moves in space when I say it goes forward; I am quite sure also that my eyes do not move forward from my ear as the tone goes on. The going forward of it is, to express it in another way, an addition to the tone in a special way. It is only a little thing when it first comes and it keeps getting bigger, there gets more of it, an increase in the tone in a special way. I am not able to say in what way, save by saying that it gets longer in time. It is almost as if you added more quality of the same sort to it."

Other evidence for the progression of the tones is found in the statement that the members sometimes fall into parts. Bo; "the members generally split up into two or three or possibly more parts." D; "I sort of divided the first member up," "the tone seemed pulsy." F; "sound seems to change in quality or intensity as it goes on"; "sound seems to go forward with certain qualitative changes upon it"; "sometimes there are two or three of these changes in the tone."

The fact that three of our observers report that the members did not remain the same in intensity or quality throughout their length, and that they nevertheless report the sound as being "all there at once" and as "having duration," suggests Meumann's distinction between succession and duration (as already quoted, p. 3) and Moede's distinction (p. 4) between duration and progression.

There seems to be agreement among the observers that the consciousness of time may be taken in either of two ways. These two ways are designated by the majority of the observers as "dimensions." One and the same experience may be taken either as a moving duration, progression, or as a static duration which we shall call "length." The word "progression" seems better suited to the non-static view than does the more commonly used term "succession," because the latter name seems to imply too definite an interruption in the experience

Summary: In these introspections we find a confirmation

of Katz' statement[33] that the "observers at first found that slight movements helped the judgment, but that soon these voluntary movements dropped out." We find the chest strains of Münsterberg, the expectation and surprise of Schumann, and in the "automatic" judgments we seem to have the "mechanical" judgments of Alvord and Searle. There is also a tendency toward "immediate" judgments, although there is little evidence that they are based merely on the duration of the tone. Of all the ways in which the tones may be imaged or represented, kinaesthesis is by far the most important for all observers, and in the case of one observer at least, Gou, kinaesthesis could not be eliminated. As we have already suggested, the reports contradict Nichols' findings in regard to the temporal length of representations of duration. We find, moreover, distinctions drawn between the two dimensions of psychological time, and introspections which are contrary to the statement that the subjective present does not possess subjective duration.[34]

Group 2

This group of experiments consists of a number of quantitative and introspective series in which a continuous sound (that given in Group 1) was to be compared with an "empty" interval marked off by two clicks.[35] The continuous sound, or the "filled" member, was always given first. In order that the results might be more or less comparable with those of Meumann, standard times of 60° (1.2 sec.) and 90° (1.8 sec.), with an interval of 2 sec. between members, were used. A slight change in instructions was introduced as the result of a procedure which most of the observers had adopted in Group 1. In regard to the doubtful judgments, the instructions now read: "If, at any time it is impossible to give anything but a doubtful judgment, ring in both possibilities, e. g., 'greater or equal.'"[36]

[33] *Op. cit.*, 321.

[34] Washburn, *loc cit.*

[35] As many investigators have already noted, there is no really "empty" interval when the time between two limiting stimuli is taken as stimulus; it is merely an interval whose *filling* is different from that of the "filled" intervals. In this paper, for the sake of convenience, the times between two limiting stimuli will be called "empty" intervals. By a simple shift of connections on the apparatus (see Wundt, *Physiol. Psych.*, III, 1911, p. 344) either member could be made to consist of continuous sound or of two clicks.

[36] In the mathematical calculations judgments of "greater or equal" are considered as "greater" judgments, those of "less or equal" as "less."

Observers: In addition to Bo, D, and F, who served in Group 1, two new observers were added. These were: Mr. H. G. Bishop (Bi), assistant in psychology, an experienced observer; and Dr. H. P. Weld (W), assistant professor in psychology, a highly trained observer. These 5 observers served throughout the remainder of the investigation.

TABLE 1

AUDITORY STIMULI

Filled—empty. Filled always the standard. Five cases each.

	S = 60°				S = 90°			
	Dl_l	h	Dl_u	h	Dl_l	h	Dl_u	h
Bi.....	−10.8°	.056	31.9°	.057	−5.6°	.033	23.8°	.037
Bo.....	−15.4	.518	36.5	.023	−6.9	.029	21.7	.025
D.....	−1.1	.033	22.6	.032	8.1	.051	12.0	.065
F.....	2.1	.025	16.5	.058	−9.5	.033	17.6	.028
W.....	−8.2	.034	20.5	.050	9.7	.017	8.8	.041

Table 1 exhibits the results of the series, the values of the Dl being expressed in degrees (50°=1 sec.). The general conclusion from the quantitative results is that: *when a filled time is followed by an empty time, the empty time is usually underestimated.* This result agrees in general with the results of earlier investigators, but no detailed comparison can be made. As has been said already, we have so few cases that our numerical results are insignificant, and the differences between our stimuli and instructions and those used by others render any explicit comparison of the figures meaningless.

Introspective results: With a change of conditions, the comparing of an empty time with a filled instead of the comparing of two filled, we find, as we might expect, at first a constant use of all kinds of aid for the judgment. As was the case in the preceding group, these aids and secondary criteria tended to drop away after a time.

Bi uses all sorts of criteria. He says: "the two members were represented in visual terms after it was all over"; "after the clicks were over, both members were run through again. This consisted in kinaesthesis in the throat"; "the length of the tone seemed to be equal to, and to be measured by, the length of a vaguely defined thing which appeared to pass before the eyes"; "tone was represented visually and auditorily"; "the tone stood out as a luminous line all there at

once, while the clicks were represented by two dark points"; "duration of the tone was carried in eye-, ear-, and throat-kinaesthesis, with also certain modifications of breathing."

Bo at first relies on visual imagery, but later turns to a kinaesthetic laying-off of the first member on the second. "First member was visualised quite passively. After the second click the two didn't come up in imagery together as before, so I voluntarily imaged auditorily and visually the first click and the beginning of the tone, and ran the time through to see which would come out first. There were organics in this judgment. The end of this course was not definite. The breathing, I think, marked the end, but I didn't know of which member it was the end. Then I got the two together in visual imagery, the lengths representing duration, and compared them." When Bo was asked whether he could make the judgment without visualising the members, he replied, "being told to judge these without visualising, is like being told to add two numbers without thinking of them." Later, however, he found that he could use kinaesthesis to carry the first member over to the second, instead of calling up two visual images after the whole experience. "I should say that my attitude toward the second member, which made me judge it as shorter, was somehow conscious as the kinaesthetic hang-over from the first member"; "along with the second member I represented the first member by a course of shoulder kinaesthesis. The second click came as a surprise. The shoulder kinaesthesis was still in full swing and I should say my judgment formed immediately"; "I am quite sure, when I get the first member represented in kinaesthesis stopping before or after the second click, that I can make a judgment, although I don't always know what the judgment should be until I have a visual image."

D seems to use a method similar to this latter one of Bo's throughout the group of experiments. "I have a muscular and organic feel which seems to originate in accompaniment with the first member. Then when the second member starts, there is a repetition of this feel which is weaker, but so far as I can see is the same otherwise. The judgment depends on the effect the second member has on this feel; i. e., when they are the same there comes a comparatively gradual relaxation from this muscular tension and organic excitement. The feel, of course, has a temporal course dependent on the length of time of the first member, it runs the same temporal course with the second member that it did with the first. When the second member stops too soon or runs beyond the temporal course of the feel, there is a change in the feel which means to me a difference in the length of time." The feel, he says, he has "characterised before as expectation of the second member." D also reports "a visual pattern of the members in three dimensions," which continues the same almost all through the series of experiments.

F considered his results physically more exact when he laid one off on the other, by means of a voluntarily recalled auditory image of the first member; "the click and an auditory image which goes through the same changes that the first member went through, together make up or *mean* a repetition of the first. I always go on with the second member as if I expected it to be equal to the first;" "there is no second member for me. The second click either breaks in upon what for me is a repetition of the first member ('shorter' judgments), coincides with the end of that repetition ('equal' judgments), or comes after the repetition is over ('longer' judgments)."

W relies somewhat on visual imagery, and more on kinaesthesis.

"Before I gave the judgment, I recalled the tone and clicks in succession auditorily and visually, and respiratorily, as though I were actually producing the tone." W does not speak definitely of "laying-off the first on the second," but he apparently does this, because he almost always reports "it is as if you expected the second click to come about the time of the end of the first sound"; "expected the second click at about the duration of the first tone, and it came earlier."

Beside these common judgments by secondary images called up after the end of the second member, or some image or representation of the first member laid along the second while in course, we find various other methods of judging. "Automatic" or "unconscious" judgments are reported at times, as they were in the first group of experiments.

Bi says: "Notice this morning a tendency for consciousness to drop out, much like the action consciousness passing from impulse to reflex"; "the click interval merely seemed longer"; "the judgment came as if from the unconscious."

D reports: "Don't think there was much of anything between the last member and ringing the bell"; "perfectly spontaneous. Just pressed the button without thinking anything consciously."

F; "second click just didn't come when I knew it should. Didn't go over the experience in image. Judgment automatic"; "after second click automatically pressed the button"; "judgment just seems to be a sort of motor judgment."

F gives two further methods by which he can judge the members, one in which he "lets the judgments take care of themselves," and another in which he takes the two members in a rhythm. "I sit back much more passively. I let the tone impress me as so-and-so long. Instead of apprehending it as a thing getting progressively longer (as I ordinarily do), I apprehend it as a unitary duration. I apprehend the second member as a unitary duration. I do not make a comparison of the two durations explicitly, but allow the judgment to take care of itself. The preparation of the fore-period and the habit of reacting seem to do all the work for me, seem to touch off the judgment reaction. Have a feeling that I am physically more accurate if I judge by the other method." This method, however, he forsook as unsatisfactory, and later tried another. "I prepared myself to perceive the whole thing in a rhythm." Such a procedure proved to be practically the equivalent of "expecting the second member to stop at a certain definite point."

W reports several times that he gave a vocal-motor judgment of the absolute length of the first member.

Three observers report a change in attitude toward the experiment as the group progressed.

Bo "took signal bell and first member passively, as a matter of course"; "maintained a careless attitude throughout." Soon after the development of this passive attitude, however, Bo adopted the method of kinaesthetic laying-off of the first member on the second; and with the adoption of the new method, his remarks on passivity cease.

F; "I believe that to-day I am taking the whole experience more passively"; "none of the experience is as clear as it used to be when I was actively attentive."

W; "general feeling of familiarity about the situation, sitting back, relaxed, less strain"; "am taking the whole thing more passively. The sound went on and, my attitude being passive, I let it go on without any effort to estimate its length or anything of the sort. Have a sort of feeling that the whole thing is becoming more mechanical,

somehow as though I were willing to give judgments without much pains."

Unless observers are questioned in regard to the interval between the members, they tend to omit all mention of it.

When Bi does speak of the interval, he usually reports it as "a blank," though occasionally he says "throat kinaesthesis repeating the tone"; "noticed that I inspired in the interval."

Bo reports occasional images and representations of the first member at this time.

D hardly ever mentions the interval, and when questioned says he has forgotten all about it.

F says: "the interval is just the same as if it weren't there," although occasionally he reports: "expectantly set myself for the first click."

W; "it's funny how little knowledge one has retrospectively of the interval; you know there is a gap there, but as to the real length of the gap you haven't much idea."

At times the observers also reported on comparisons which they were not instructed to report upon, as, for example, the comparative lengths of the first members of succeeding pairs of stimuli.

Bo: "There is a tendency always to judge not only between the tone and clicks presented in any pair, but also between them and those in the preceding pair. This time the tone was shorter than the preceding tone, and the clicks longer than the previous clicks. These judgments force themselves into consciousness along with the judgment I'm supposed to make. They come perfectly spontaneously."

D: "There seemed to be quite a difference between this first member and the first members of the non-introspective series to-day."

W: "There seems to be a sort of comparison of the length of the first member with the 'average length of the first members.'"

As was the case with Group I, we find in this group a number of statements concerning the durational aspect of the experiences.

Bi: "there is not much to be said about the tone. It merely seemed to exist for a certain time."

Bo: "I doubt very much whether one ever recalls duration as duration. In recalling an interval a great part of the durativeness is the acompanying kinaesthetic course."

D: "The tone seems to be a continuous thing; when you get to the end, you still have the first part. The second member (empty), however, seems disjointed"; "when I leave the muscular feel out of consideration or try to prevent it, the second member becomes just two disconnected sounds without relation to each other or to the rest. The first member is a compact whole and has in itself duration, i. e., a continued stimulation, so that I hear the sound right along, the beginning seems to carry over and stay in consciousness until the end comes; whereas the second member seems like two disjointed points and the interval between them has no quality of duration in itself except as I put it in by means of organic and muscular sensations. The only temporal thing about the second member seems to be that the two sounds are not together."

F: "In spite of its qualitative and intensive changes, the first member appeals to me as one tone lasting a certain time. Its duration *is*, or has something to do *with*, or is impressed on me *by*, these changes;" with the passive attitude, "the qualitative aspect of the tone doesn't impress me. All I can say is, the tone impresses me as a duration;" "the first member is apprehended as a single thing *going forward*. I don't know what going forward means save this, that the beginning

of the tone is in some sense still in consciousness when the last of it comes. In spite of its being successive, the tone is in a sense simultaneous."

W: "Am wondering whether both members are not altogether in consciousness, i. e., in the conscious present."

Summary of introspections on Group 2: With new conditions, secondary criteria are again prominent at first. Although these tend to become less prominent or to drop out, the tendency is, on the whole, less marked than it was in Group 1. It would seem probable, with the increase in practice, that the mechanising of the judgment which was so clearly marked with some observers in the first group, would here become still more prominent. On the contrary, many secondary criteria are reported near the end of the group. The continued use of secondary criteria may, then, be due to the difference in the stimuli in the two groups. The difference in the case of judgment of these groups comes out more significantly in the remarks made in connection with Group 6 and will be discussed in detail later. Moreover, in this group we find distinctions drawn (especially by F) between various attitudes which may be adopted toward the experiment. The "passive" attitude which he takes at times led later to a change of instructions to the observers (see Group 6). The "taking the whole thing as a rhythm" which he reports seems really to amount to an expectation of the end of the second member at a certain time, and under the latter terminology will be found in much of the later work of all observers. The fact that, unless the observers were instructed particularly to report on the interval between the members, they usually neglected to mention it or spoke of it as a blank, brings out rather clearly the fact that an observer is likely to report what he is set for (either by the experimenter or by himself), and that one reason why so many secondary criteria appear in the introspections may be due to the fact that the observers were instructed to "be on the look-out for secondary criteria." Further reference will be made to this influence of *Aufgabe* on the report under the experiments (Groups 6 ff.) which were made under other instructions. Finally we continue to find introspective evidence as to the ultimate nature of duration and its two 'dimensions.'

Group 3

This group of experiments is like Group 2 in having both quantitative and introspective series, in using both filled and empty times, in the standard times used ($60° = 1.2$ sec.; $90° = 1.8$ sec.), and in the instructions given to the observ-

ers. It differs from the second group in having the empty time given before the filled, and in having each day the introspective taken before the quantitative series.

TABLE 2

Auditory stimuli. Empty—filled. Introspective series before the quantitative. Filled time the standard. Five cases each.

	S = 60°				S = 90°			
	Dl_l	h	Dl_u	h	Dl_l	h	Dl_u	h
Bi	18.3	.012	27.7	.022	−8.8	.016	29.5	.021
Bo	13.4	.054	−1.1	.018	10.0	.032	3.0	.023
D	17.3	.077	6.4	.028	33.2	.057	18.2	.028
F	−5.0	.044	9.7	.033	−10.1	.460	28.2	.022
W	16.1	.055	−19.4	.018	30.0	.011	−1.4	.015

The most noticeable thing about the quantitative results is the *great variation in the limens.* F shows the same tendency that he showed in Group 2, to overestimate the empty interval; W and Bo, on the contrary, tend rather to overestimate the filled interval. The introspections may throw some light on the variations.

Introspective results: The introspective reports for this group give comparatively little that has not been at least hinted in the preceding groups.

Bi still clings to visual images, giving the temporal relations of the members as spatial relations. These representations usually arise during the course of the members, and are held together for comparison.

Bo continues to parallel the second member with an "organic pattern (respiratory and neck-kinaesthesis)". In the interval between the members Bo often reports images of the clicks, and distinguishes between images of the continuous tone and those of the empty interval. The latter differ from the former; "a reproduction of the first member, I think entirely auditory. It baffles me completely to say just how it is that I get those two clicks after one another. There doesn't seem to be any lapse of time in their succession. I think I mean, however, by lapse of time, the organic accompaniments. In other words, the successive separateness of the imagined clicks is so unlike duration, as I generally mean duration by means of organic processes, that it scarcely seems as if it should be reported as such;" "the clicks came up in auditory imagery, visually supplemented, and as separated without a definite durational displacement."

D has difficulty, not only in imaging the clicks at their proper distance apart, but also with the first member while it is going on. "The time between the clicks as far as I can see now is practically empty

and, as I remember, there is nothing temporal about it, i. e., I have no definite idea of how far apart the clicks were in time except the general notion that they weren't very near together, because by the time the second came, I had completely lost the first;" "the judgment is not spontaneous. It isn't self-evident which one of the members is longer and I usually arrive at my judgment by a process of elimination. I usually remember fairly well what the length of the second member is, and make a guess at the first. I can usually tell when the first member is very short or very long, but, of course, these don't happen very often. When it is in the middle ground, I think to some extent I neglect the particular member, and compare the second with what would be a 'medium length' member." Later, D voluntarily sets up a course of organic and muscular feels along with the first member, in order to have something to carry over to compare with the second. "I am compelling myself to carry the first over (organic and muscular) to compare with the second."

F continues one of his old methods, that of apprehending the second member as a repetition of the first. "The second member is perceived in the sense of a repetition of the first. I am uncertain whether I hear two clicks, image two clicks, or whether I merely *mean* two clicks in the case of the second member. I incline toward the second possibility. I do hear the tone;" "the judgment is quite an automatic thing. Half a second after I have pushed the button I couldn't tell how many times I pushed it. I certainly push it before I even have time to go over the thing in imagery."

W at first relies to a great extent on secondary criteria of several kinds, but reports with more and more frequency as the experiments continue many judgments of absolute length; "some slight strain before the second click made the first member seem absolutely long, without seeming to compare it with anything"; "after the clicks came I said 'short'"; "when the tone was ended I said 'short,' and rang the judgment 'shorter.'" W also reports occasionally as follows: "One is strongly tempted in this case to say that one interval is longer than the other and that's all there is to it. They're so short that the usual criteria are apparently, as far as I can discover, not present. The visualisation is fully as immediate a thing as one can imagine. There is no effort to visualise, it is simply there. The interval between the clicks is so long or so short, simply *there*, and the line representing the tone is so long or so short, simply *there* again, and in this case, at least, there is no attempt to measure one beside the other, the judgment is immediate; you *know* that one is longer, that is all I can say."

Some observers give evidence that the length of the members varies with the manner in which it is represented.

Bi: "as I think of the clicks now in visual terms the distance between them is very great, but in some other terms it was considerably less. I can't tell what these other terms are. They seemed to be a vague bodily kinaesthesis localised more in the head and eyes than anywhere else. The difference between these two values of click interval may possibly be the difference between the interval taken as filled time and the interval taken as empty time. The click interval seems to have empty time value while it is going on, but when the tone comes, the click interval seems to be filled up with a tone;" "this time the long value for the click interval didn't make its appearance"; "could judge the click interval either as immensely long or as awfully short"; "some trouble with the judgment because the clicks were in kinaesthesis, and the tone in vision."

Bo reports: "The members kinaesthetically together, but immediately afterward I got a visual image of the first member ending first"; "second member and represented first member ended coterminally. Immediate visual image in which the second member was seen as shorter than the first member, and a sort of organic tag to the visual imagery, seemed to verify this decision."

Summary of introspections for Group 3: The chief points here are that it seems much more difficult to "carry over" a first member when it is empty than when it is filled, and that all kinds of evaluations of the empty interval seem less certain and less spontaneous than evaluations of the filled interval. An important point for the explanation of the quantitative results is that the empty interval seems to vary in length according to the way it is represented. It is impossible from these results to say which representations seem to be the shorter. Another possible explanation for the irregularity of the quantitative results lay in a suggestion made by F at the end of the group. This observer had objected more or less all through the group to the plan of having the introspective series each day before the quantitative series, as he got into the introspective mood and it was difficult or impossible to get back to a quantitative set. It seemed that the position of the introspective series might have affected the different observers in different ways, and Group 4 of the experiments was made to test this point.

Group 4

This group consists of quantitative experiments similar to those of Group 3, except that no introspective series were given at the beginning of the hour. Some of the observers had noted during the last group that certain of their 'equal' judgments were judgments of equality,[37] while others were simply 'doubtful' judgments. In this group all observers were requested to report judgments of true equality through the speaking tube, while the merely 'doubtful' judgments were rung in as all 'equal' ones had been formerly. In the construction of the quantitative table given below, all "equal" judgments are considered together. In this group the experimenter timed the interval between the end of the second member and the ringing of the judgment,[38] although the observers did not know this was being done.

[37] Bo reports: "The judgment 'equal' really meant uncertainty as to 'longer' or 'shorter,' a frequent meaning of 'equal' for me."

[38] By starting a stop watch when the last contact was moved and stopping it when the first ring came.

TABLE 3

Auditory stimuli. Empty—filled. Filled the standard. Ten cases each. No introspective series. Distinctions drawn between "positive" equality and "equal doubtful" judgments.

	S = 60°				S = 90°			
	Dl_l	h	Dl_u	h	Dl_l	h	Dl_u	h
Bi	9.3	.073	17.6	.031	7.0	.025	27.8	.187
Bo	22.8	.036	−1.9	.042	21.8	.025	20.3	.032
D	24.1	.092	−4.6	.070	37.2	.023	− .6	.025
F	−1.1	.054	17.8	.040	−5.4	.023	33.6	.030
W	26.1	.093	−20.0	.043	16.8	.025	4.1	.046

If we compare this table with Table 2, we find no apparent reason for supposing that the position of the introspective series was significant in the quantitative results. On the contrary, Table 3 shows for over half the observers a wider range between the two limens (this may be due to an increased emphasis on the possibility of "equal" judgments given by the changed instructions in regard to the equal judgments); shows no marked increase in the size of the h; shows negative limens for the same observers (except the one slight change from negative to positive in the case of W); and even shows two new negative limens in the case of D. We must conclude, therefore, that the wide individual variations in Table 2 are not the direct result of the position of the introspective series, but are probably referable to some peculiarity of carrying over an "empty" time to be compared with a filled. It will be remembered that the different observers used a variety of methods, differing from observer to observer and for one observer from day to day; and it seems natural that such a range of possible representations of the first member should result in widely divergent results.[39]

[39] Katz (*op. cit.*, 312, 324, etc.) insists that it is possible to compare the results of different observers only when we have found the interval most advantageous for each, and when we require every observer to behave in the same way in the interval between the members; one should not be allowed to call up the first member in imagery while another does not, and so on.

TABLE 4

A comparison of "equal" judgments, divided into "positively equal" and "equal doubtful," made in Group 3 of the experiments.

	S = 60°					S = 90°				
Total number of	Bi	Bo	D	F	W	Bi	Bo	D	F	W
"Positively equal"	22	21	36	26	0	13	45	45	25	0
"Equal doubtful"	33	21	4	21	32	36	28	16	27	60

From this table it appears that the greater number of D's equality judgments are judgments of "positive equality," whereas all W's judgments are judgments of "equal doubtful." Upon reference to the introspective records, a parallel distinction between these two observers is found; D persistently relies on his muscular and organic representation of the first member as compared with the second while the second is in progress. In other groups (p. 15) he says that if this "'feel' is left unchanged by the second member, the second is judged equal to the first; if it is changed by the 'feel' of the second member, the judgment is 'longer' or 'shorter'." With such a method, the judgment would tend to be that the second was positively equal to the first, rather than doubt whether it were longer or shorter. W, on the contrary, relies to great extent on judgment of the absolute impression of the members, and so is set to get the second as "long" or "short"; and in the cases where they are near together, would naturally ring a judgment that meant he could not decide whether the second were "long" or "short." The other three observers seem to lie between the extremes of D and W in their methods of judging and would, therefore, be expected to lie between them in the kinds of equal judgments passed.

TABLE 5

Average time in seconds between the end of the second member and the beginning of the ringing of the judgment, in experiments of Group 4.

Judgments	S = 60°					S = 90°				
	<	=	>	< or =	= or >	<	=	>	< or =	= or >
Bi.....	1.2	1.8	1.1			1.1	1.4	1.3		
Bo.....	2.2	2.7	1.5	4.9	5.1	2.0	2.5	1.7	5.9	3.3
D.....	1.6	2.1	1.3			1.4	1.9	1.3		
F.....	1.2	2.0	1.3	2.8	2.9	1.2	1.6	1.4	2.2	3.2
W.....	1.8	2.9	1.1	4.5	3.5	1.4	2.5	1.2	3.0	3.2

The first conclusion from the table is that the judgments arranged in order, from that taking the longest to that taking the shortest reaction-time, stand as follows: less(?); greater(?); equal; less; greater. This is, of course, natural enough, and agrees with the introspections, which often report, when the second member is much longer than the first, that the judgment was ready as soon as the second member reached the place at which it would have stopped if it had equaled the first member; in such cases the observers often reported that they waited for the second member to finish sounding before ringing the judgment.[40]

Group 5

This group consisted of a few merely introspective series, introduced to see what the effect would be if the observer did not "carry the first over" to compare it with the second. The simplest method of assuring the desired condition was the use of simultaneous instead of successive tones. Two Stern variators set approximately for 400 and 900 v. d. and so chosen that they did not beat or make an unpleasant discord were placed at either side of the observer. The observer was told that he would hear these tones together, and that he was to judge which of the two ended last, and to give an introspection on his experience.

[40] Katz, *op. cit.*, 447, says that the "judgment greater is always more sure than the judgment less." This agrees more or less with statements of our observers; "was certain of the judgment, though that certainty may have been merely that I reacted very quickly," etc. We should therefore expect the more certain judgments to show the shorter reaction times.

The introspective results proved to add nothing to our data, but they are quoted here for the sake of completeness.

Bi: "Judgment depends upon the fact that the sensation in the left ear lasted longer than the one in the right ear. With the judgment I nodded my head toward the left."

Bo: "Left stopped (I suppose a visual image meant the stop); and at once very smoothly, as if it was already habituated, attention (i. e., ear and eye-kinaesthesis) went to the right."

D: "the decision which is longer depends on first, the localization, whether it is sensation in the right or left ear that becomes attended to; second, on the pitch, for I know the lower pitch and bigger volume is on the left."

F: "judgment automatic, just a nod of my head in that direction"; "attention caught by the high tone sounding alone, and on that basis I judged automatically by a shift of my head."

W: "Tone to my left suddenly became clearer, involuntary movement in that direction"; "distinct sort of thing, that something was going on in the left ear when there wasn't anything in the right."

We had now completed sets of experiments with two filled, filled and empty, and empty and filled intervals. We had found many varieties of criteria for the judgment, particularly where we used both filled and empty times. The filled times were reported as "more durative" than the empty, and as it was the durativeness in which we were particularly interested, it seemed useless to complete the set of experiments by adding a group in which two empty times were compared.

It will be remembered that F reported occasionally "taking the members passively" (p. 16). Meumann had demanded a "passive" attitude with his observers; and Katz [41] replies "I can only say that when I attempted the behavior proposed by Meumann, this behavior not only caused a great deal of difficulty and a feeling of greater uncertainty with the judgment, but the judgment was not so accurate as with the behavior formerly followed," *i. e.*, when every observer followed the procedure which he deemed to procure the best results. Katz says, moreover, that "with Meumann's proposed passive behavior, the judgment is very uncertain. The sounds really come to consciousness isolated. The experience lacks the continuity of temporal course procured by strain sensations." [42] It therefore seemed advisable to carry on at least a few experiments with "passive" instructions.

[41] *Op. cit.*, 337.
[42] *Op. cit.*, 416.

Group 6

This group consisted of introspective series in which the three previous orders of filled-filled, filled-empty, and empty-filled times were used and in which the instructions were: "As far as you can, give yourself up passively; let the members impress you passively; do not in any way 'lay off' the first on the second member." In this group only one standard, that of 60° (1.2 sec.), was used. Observer D did not serve in this group.

Introspective results: At first Bo reports the uncertainty of judgment and the isolation of the members that Katz had mentioned.

(Empty—filled) 'Determined to be passive, attention on clicks, and body-kinaesthesis and ear-kinaesthesis of attention. No reference to final judgment. Interval between members very confused, no reproduction of the first member, no specific anticipation of the second member, general anticipation involved in reference to instruction, etc. Then gave myself up to the second member. Giving-up is a sort of bodily kinaesthetic slump *plus* heightened ear-kinaesthesis which means attention *plus* the auditory processes. No explicit reference to the first member during the second, although I suppose a certain kinaesthetic uneasiness and eye-movement referred either to the first member or to the coming judgment. After the second member came a blank which was body-organics, a self-consciousness. Then I felt confused because no judgment came and I tried to get one immediately (mostly kinaesthesis). Then I reinstated the members, first one and then the other, in visual, auditory and kinaesthetic imagery. No judgment at first, the two just did not seem comparable, not greater, nor equal, nor less. Finally I got the two together visually, a concurrence which does seem to be possible in auditory-kinaesthetic reproduction. The two that stood together were the same length, but I did not have any great certainty that this visual image really represented the original." "No judgment at all after the second member. I knew that both members were rather short absolutely. Completely baffled, however, as to the judgment." "Gave myself up to the first member. After the end of it, the member was repeated in similar terms (audition and ear-kinaesthesis). The second member was clear in auditory processes, very detailed visual processes, and the kinaesthesis of auditory attention. After the second member there was no judgment at all." It will be remembered that Bo had always taken the members "very actively." He was accustomed to run the first member in organic and kinaesthetic imagery along with the second member; and, evidently, the instructions to dispense altogether with this procedure had the effect of setting him not to judge. The possibility of judging the members by any other means than by voluntarily aroused images of the two after the stimuli had ceased or by running a reproduction of the first along with the second had not occurred to him before, and so the new instructions baffled him. It is likely that in a similar way Katz' observers who were accustomed to judging by strain sensations were likewise baffled. Bo, however, in the later part of this group of experiments to a great degree stopped reporting uncertainty. He reports: (filled—empty) "The first mem-

ber was clear throughout in the typically passive way. I think this typical passivity is that the tone was clear auditorily but all the kinaesthesis was irrelevant. The judgment came by way of an indefinite visual image and hand-kinaesthesis. I am not sure the visual image was essential. The feel of my hand wanting to press the button came just as soon and might have proved an adequate cue. I am rather set under this *Aufgabe* to make the judgment on any cue at all, I am so afraid of not being able to judge at all." As the experiments progressed, Bo reports judgments made on the basis of imagery arising at the end of the second member and apparently not sufficient to carry the meaning which it does seem to carry: (filled—empty) "After the second member there was a blank, almost meaningless kinaesthetic pause, a waiting. Then all at once there was an experience which *meant* 'equal.' It wasn't verbal, it wasn't numerical, i. e., it required subsequent processes for the idea of two rings to come up; it *did* mean a definite decision, and it *was*, as far as I can tell, nothing but a thing like a kinaesthetic twitch inside my head and perhaps an eye-kinaesthesis *plus* a vague background of visual imagery. How on earth such a thing gets to mean decision, not to say equality, is more than I can say." Still later, Bo gets still further away from the baffled uncertainty that the passive attitude brought at first. (Empty—filled) "Very meagre consciousness. The experience is like that of the mechanical judgment which runs itself off without consideration." "Judgment seems to be getting automatic and to have less to do with consciousness. Feeling of certainty as to the judgment without, however, anything conscious like comparison. I cannot explain the formation of the judgment. There was no reference to the first member after it lapsed, very little to the second, no comparison or effort to compare, no simultaneous visualisation or imagining." "I am not aware that I anticipated that the ring would be 'one.' I knew it was one as soon as I had rung." (Filled—filled) "At the end of the second member there came in with no effort, I think no pause, easily, passively, the idea of 'longer.' I noted that the idea was very thin and simple, that it had no obviously explicit reference to the tones, and I wonder now if it was anything more than a feeling of certainty. Think the ringing was quite mechanical." "I think of it as a reaction, not as a judgment." We have here, then, in the case of Bo an apparent dropping out of consciousness with the passive instructions. It seems probable on this evidence that if Katz' observers had been compelled to continue the passive attitude long enough, they too would have lost the uncertainty, etc. The loss of uncertainty as to the judgment may mean that with the passive attitude there is less stress on the observer to judge as accurately as he can; but this point can be settled only by quantitative series. (See Group 7.) The question of the significance of the passive attitude for our problem will be discussed at the end of the experiments performed under this instruction. (Filled—filled) "I can judge better if I don't attend too well to the tones."

Unlike Bo, the other observers did not report themselves as ever "completely baffled," although they show in Group 7 (given under similar instructions) that the adoption of the passive attitude is confusing and often results in no judgment (see pp. 29ff).

Like Bo, all report judgments without conscious comparison. Bi (empty-filled) "heard the first click, and then later heard the second one. I may have had a slight idea of the amount of time between them, but it was certainly less definite than in other experiments. The

course of the tone was quite indistinct too. I heard it, but didn't mark off the ends of it at all distinctly. The judgment came spontaneously, as nearly as I can tell, touched off by the realisation that both members had been given; i. e., just as soon as I realised that both members had been given, I seemed to have my judgment ready. Except for the fact of equality there was nothing else conscious except the vaguest sort of kinaesthesis." (Filled-filled) "I think so far as consciousness goes, passive means unattentive"; (filled-empty) "at the end I began to wonder what the judgment was, and what I must ring, and when I came to ringing, I found I had already done that."

F says: (filled-empty) "Can't be analytic and at the same time passive, somehow. All I know is that the first member seemed longer than the second." (Empty-filled) "Obeyed instructions as far as I know, and the judgment went perfectly easily, didn't lay one off on the other"; "second member did seem longer. My thumb presses the button, that's all I know." (Filled-empty) "First member struck me as being absolutely long. The second member was perceived as a rhythm. Automatic judgment. Thumb just pressed the button." (Filled-filled) "Can't find a single thing in the way of mental process or in the way of changed intensity, changed general quality, changed strain, or anything of that sort that I can tell represents the knowledge that the second has gone on as far as the first; but I do *know* somehow or other, consciously or unconsciously, *precisely when* that second has gone on as far as the first."

W seemed to have less difficulty than the other observers in adopting the passive attitude. He reports: (filled-empty) "When the clicks came, the judgment was touched off at once. There was no comparison or anything of that sort." (Filled-filled) "The tone seemed very long. So far as I know there was no secondary criterion, and yet the thing seemed to last interminably. So far as I know, there was no basis for the judgment except that the first tone was long and the second was shorter." (Filled-empty) "Am rather impressed by the tendency for secondary criteria to come in when there is doubt"; (empty-filled) "I have the general *Aufgabe* to take the thing naïvely, but the determination to report makes it a good deal more difficult to maintain this *Aufgabe*"; (filled-filled) "I have always found that the successful inhibition of secondary criteria didn't interfere one whit with my ability to judge, or with the experience of going-on-ness (or duration, if you like). I've usually found, however, that when one criterion was inhibited another was very apt to take its place, and this I now believe was due to a predisposition to report and to make an accurate report, not only as regards the mental processes, secondary criteria and everything that's there, but also as regards the judgment itself. Under the present *Aufgabe*, the feeling of necessity that I must make a very accurate report as regards the judgment is lacking, and the secondary criteria fall away, so that I seem to be left with nothing but the bare experiences of going-on-ness."

Summary of introspections: Under the passive instructions, attention "tends to be lower" (cf. pp. 31f.), there is less determination to be "analytic" and to report in detail. More discussion of the influence of these instructions will be given in the next section, in the discussion of quantitative series taken under the same instruction.

What Bo means when he says he can "judge better if he

does not attend too well" needs some explanation. Starting from a definition of attention as sensory clearness, he says that, even at the times when the members are clear, he does not generally report himself as paying "good attention" unless he "reacts upon them by associative supplementation." Such attention is evidently "strained" attention or "active" attention. The disagreement among various investigators (Katz, Meumann, Nichols, Kahnt, etc.) is doubtless attributable to a difference in definition of the terms "passive" and "attention." [48] If by passive one mean 'not paying strained attention,' then since, as we have seen, our observers tend to discontinue the large strains and body-movements which at first seemed necessary to the judgment, our results may be taken to agree with Meumann; whereas, if by passive is meant something like a state of irresponsible reverie, our results (p 32) may be taken in exactly the opposite way.

Group 7

This group consists of a series of quantitative experiments with a few general introspections at the end. Three orders were used; filled-empty, empty-filled, and filled-filled, and two standard times 60° and 90°. These experiments were given with Meumann's passive instructions.

TABLE 6

Auditory stimuli. Passive attitude. Filled—filled. Second member the standard. Five cases each.

	S = 60°				S = 90°			
	Dl_l	h	Dl_u	h	Dl_l	h	Dl_u	h
Bi	10.0°	.020	4.3°	.023	25.9	.037	−11.1°	.035
Bo	18.3	.119	18.5	.024	18.8	.042	−25.0	.007
D	14.1	.080	−2.4	.036	32.1	.023	1.3	.104
F	6.2	.068	2.6	.077	9.1	.080	3.9	.070
W	10.2	.072	−4.1	.080	16.2	.037	8.0	.015

[48] Katz reports (*op. cit.*, 321), that his observers at first found that slight movements helped the judgment, but that soon these voluntary movements dropped out, because they "*took too much attention*" (italics mine). If, then, strained attention really means increased attention to bodily strains and correspondingly decreased attention to the members to be compared, it is small wonder that some writers have taken the best condition for the comparison to be "not too high" attention.

TABLE 7

Auditory stimuli. Filled—empty. Passive attitude. Filled the standard. Five cases each.

	S = 60°				S = 90°			
	Dl_l	h	Dl_l	h	Dl_l	h	Dl_u	h
Bi	-33.6	.064	60.4	.026	-20.6	.013	43.6	.059
Bo	-18.7	.019	66.5	.013	-23.0	.020	48.8	.026
D	3.8	.025	29.1	.022	19.5	.002	45.6	.016
F	-27.9	.031	32.4	.038	-22.2	.032	28.4	.050
W	-15.1	.035	30.6	.030	-4.1	.022	36.9	.021

TABLE 8

Auditory stimuli. Empty—filled. Passive attitude. Filled the standard. Five cases each.

	S = 60°				S = 90°			
	Dl_l	h	Dl_u	h	Dl_l	h	Dl_u	h
Bi	15.2°	.024	14.4°	.032	-9.0	.029	25.4°	.028
Bo	12.0	.044	22.6	.012	16.5	.012	38.6	.014
D	18.1	.050	-9.4	.119	18.6	.022	21.5	.020
F	-8.6	.028	20.2	.046	-18.8	.016	41.7	.012
W	23.0	.061	5.5	.020	-6.7	.006	35.0	.024

On account of the lack of quantitative results for Group 1, we are unable to compare the results for two filled times under the different instructions. With the filled-empty order, we find much smaller limens under the original instructions than under Meumann's 'passive' instructions, and in general the values for *h* run higher with the "active instructions." The tendency in the case of the empty-filled times is not so marked, although the *h* show a decided tendency to be higher with the active attitude. These results, then, seem to uphold Katz in his statement that judgments under Meumann's instructions are less accurate than those under active instructions; and since the observers report that passivity in general means less attention, they refute those of Meumann, Nichols, and Kahnt in having the results more accurate if attention is

high. However, as has been said (p. 29), these writers are doubtless using the word "attention" to mean "strained" attention.

Introspections on Group 7: Any introspections offered by the observers day by day were recorded, and at the end of the Group the experimenter asked for general introspections over the whole series.

Bi: "Passivity seems to mean that I am to listen to the members, but not to listen hard enough to call up imagery of any sort. Try just barely to hear the tone, to have nothing but the auditory sensation. All repeating of the first member is ruled out in the passive series. There are all degrees of certainty, sometimes the judgment came as automatically as could be. Any click interval is harder to judge than the tone interval. I feel more sure of my judgments with the active attitude, though there are certain ones with the passive attitude when it seems to go off well."

Bo: "Two tones are much easier than clicks and tone." "With two tones the judgments are much more immediate. Sometimes the passive attitude gets away with me and attention is poor. Then I have to compare the members in imagery and subjective certainty is much less. I think subjective certainty is much greater with the active attitude. It certainly is very low with 'clicks and tone,' although with a few stimuli of extreme length subjective certainty is always very high. Attention is certainly better with active attitude, at least on the average. It certainly fluctuates with the passive. You tend not to attend when you are passive."

D: "It is easiest to judge with two tones, is quite easy with these, in fact, and for that reason the matter of passivity has not been at all difficult with these, and I have a feeling that my judgments are far more accurate with both tones than with clicks and tone, i. e., that I can judge smaller differences. It was harder to be passive with the tone and clicks. Subjective certainty was certainly greater with the active instructions, except for the case of both tones, where it didn't seem necessary to be active. The passive attitude has very little muscular strain with it, whereas the active attitude has a rather indefinite muscular tenseness. With the passive, I have lapses of attention."

F: "I can distinguish several different attitudes which you can take toward the thing. If you give yourself up passively, you find yourself lost, no immediate judgment coming. You try to make a judgment, then that involves visualising the two members with eye-kinaesthesis helping out, and in a sense that is laying one off on the other, so you give that up. Then you put the emphasis on 'not laying one off on the other' and tell yourself to take the two members merely as two times. Then two things may happen: You may find that taking the click interval as a time means kinaesthesis and you find that you neglect the tonal aspect of the second member, don't attend to the tone, second member is tone in the background and *kinaesthesis* in the foreground, and that means you're laying off one kinaesthetically on the other; *or* you do as I have been doing lately, tell yourself you will *follow* both of them, glide along with both of them. Haven't analysed that entirely, but you seem to glide along with the first one so far, and you glide along with the second one so far, always somehow in comparison with the amount you have glided along with the first, so that in this case you have practically made the empty interval

a thing that you follow as you follow the changing, the going-forward tone. . . . You can take the tone as a *time* between its beginning and end, in which case you don't attend to the tone as a tone, or you can follow the tone, and as a matter of fact you can take *both* these attitudes towards a single member, though not at once. The judgment is not immediate and it makes all the difference which of the two attitudes you take. There is a difference between the time between two points and a time that goes on and you follow; the time that is extended and the time that goes on. The natural time between the clicks is the first kind, and the natural and immediate time of the tone is the second. So that you really have to make one time over into the other by an attitude or a determination (like the determination not to take the second member as a tone) to get an immediate judgment." "Real difference between the two members temporally. In the first member the time of the first member somehow doesn't *move*, but rather *intensifies* or grows, as though you watched the time; in the second member, you follow the process, the time moves. . . . The time of the first (clicks) is a dead sort of thing; the time of the second is alive; the time of the first member is much more all-there-at-once than is the time of the second member." F here is apparently making the distinction which Moede[44] draws between duration and progression. We shall refer to this point later when in the conclusion we discuss the distinction between duration, temporal course, progression, etc.

F gives various other attitudes which he can take toward the comparison, such as taking the members as absolute impressions, etc. Subjective certainty is greater with the active attitude, particularly in the case of filled-empty and empty-filled. "I think secondary criteria are more apt to come in with the active attitude." "Strain sensations are, I think, more prominent with the active attitude, at least, since introspection is easier, they are found more, and the same holds true for images."

W reports: "Subjective certainty greater as a rule with the active, attention better with the active, and secondary criteria tend to come in more with the active. It is much easier to judge two tones than tones and clicks."

Beside the introspective evidence, it is interesting to note that during the course of the experiments Bi reported that he couldn't make one judgment because he was "too passive"; Bo remarked after some series with empty-filled order: "On the scale of 10, subjective certainty with these instructions is about minus 3"; in one case he said he had "no impulse to judge," and twice that he "forgot to judge." D reported twice that he had "no judgment, was too passive" and once that he "didn't make any judgment"; and F said once that he was "too passive" to judge.

Under Meumann's passive instructions, then, strained attention tends to become lower. Subjective certainty and even the determination to judge are less than under active instructions. We find, moreover, that the tendency not to report secondary criteria is so great here that it is sometimes impossible for the observer to say whether strains, weak images, and so on, are present or not. We have here good evidence

[44] *Op cit.*, 366.

that Meumann's observers, being under passive instructions, could not have found the strains, etc., even if they had been set to look for them; and as they were instructed definitely against getting them, it is no wonder that they did not. Neither is it any wonder that other investigators, working under a different *Aufgabe,* have strains, etc., continually reported. Meumann seems not to have worked with that degree of practice under active instructions in which, although the large bodily movements have disappeared, there still remains a definite kinaesthetic carrying-over of the first member. If he had, he might have found, with us, that accuracy is higher under active than under passive instructions.

Group 8

With the close of the set of experiments under the passive instructions of Meumann, we seemed to come to a natural stopping place. Nothing more was to be hoped from a continuation of work with either of the two instructions (active and passive) that had been used, and no other instructions had been suggested either by the introspections of the observers or in the literature. The stimuli used were, therefore, changed, and the temporal judgment of two continuous lights was investigated.

Apparatus for lights: The apparatus already described, which was used for the control of the length of the auditory members, was again used for the visual stimuli, with the exception that only one contact was used and that this was moved by both pairs of arms as in Group 1.

The arrangement of the stimulus itself was as follows. A ground-glass electric-light bulb was placed in a sound-proof box, behind a lens which projected through the side of the box toward the observer. Black paper was pasted over the lens, in such a way that the spot of light seen by the observer was 3 cm. in diameter. White paper was fastened on the outside of the hole through the box to make the light of a moderate, pleasant intensity, after the observer had become adapted to the darkness of the room. Between the light and the lens was a screen with a hole of the size of the opening of the lens. At either end of the screen were strips of tin at right angles to the cardboard. Two electro-magnets were so placed at the ends of the screen that, when a current was passed through one of them, the tin at that end of the cardboard was held against the magnet and the hole in the cardboard came over the opening of the lens, and the observer saw a circular spot of light; when the current was broken through that magnet and made through the other magnet, the tin on the other end of the screen was held to the second magnet, and the light was cut off. By means of a switch the experimenter could keep the screen held over to shut off the light until the kymograph had attained maximal speed; then, when the switch was turned, the light remained off

except between the times when the first and second, and the third and fourth arms moved the contacts. Tests were made to discover the difference in the time for which the light was visible and the reading on the apparatus, and the error ever exceeded 2°, or .1 sec., with an m.v. of less than 2%. A pin-hole was pricked in the cardboard screen and in the paper which reduced the intensity of the light, so that when the screen shut off the light, there was left a faint glow as a fixation point.[45]

The *instructions* for this group of experiments were worded in a manner slightly different from that used with the auditory stimuli. Up to this time, the use of the word "duration" had been carefully avoided by the experimenter; but as the experiments were drawing to a close, and as, after the temporary introduction of the passive instructions in sequence to the original instructions, the results with the new stimuli would not in any case be truly comparable with the previous results, the instructions were worded to emphasize the term "duration." They were: "You will be shown two lights of the same or of different durations with an interval between. You are to judge whether the second is longer than, shorter than, or equal to the first in duration." Quantitative series were followed each day by introspective series. Only one standard, 60°, was used.

TABLE 9

Visual stimuli. Filled—filled. Ten cases. Second member the standard

	S = 60°			
	Dl_l	h	Dl_u	h
Bi	10.6°	.126	5.0°	.062
Bo	43.2	.022	−1.7	.023
D	22.4	.034	12.5	.046
F	.6	.061	7.4	.031
W	16.5	.048	−4.0	.042

The results for Bo are markedly different from those of the other observers, and show apparently a great time-error, for the first member is greatly overestimated (or the second greatly underestimated). The explanations are to be sought in the introspections. A similar but smaller time-error shows

[45] An attempt was made at first to use the apparatus described by Moede, *op. cit.*, p. 345, but it proved impossible to get a light from a Geissler tube which did not flicker.

in the cases of all but F. Bo and D have the greatest "equality zone," F the least, and Bi and W stand between. Bo's *h* is also small.

Introspective results: We find again gradual dropping-out of consciousness; and we seem to find some effect of the previous passive instructions.

All but one observer note that the light seems to radiate out from the spot. Bi: "The light seems to radiate from the spot during the stimulation." Bo: "The first member got very rapidly brighter until it was dazzling and streaming." D: "The light didn't come instantaneously, but it seemed to open up from around the fixation-point." F: "The first member seems to grow from the center."

As to the mechanism of judgment; Bi: "What I particularly noticed was that about the middle of the second member I found myself taking a new grip on the bell, and actually had to stop to keep myself from ringing before the second member was over. As nearly as I can tell, I didn't realise I had made the judgment, till I found my hand starting to ring. Don't think I was conscious of the first member at all after it had stopped"; "Don't remember much of the first member; nothing but a sort of impression that it had been presented for a certain time and was now over. At a certain point (where the first member would have ended) in the second member, wrist strain appeared. The laying-off was not conscious;" "First member was so very short that it seemed a foregone conclusion that the second would be longer;" "Suddenly when the second member had been going for a short time, from somewhere came a feeling that this member was different from the first, was longer, and all the time after this was really just added on. I didn't intend at a certain time to judge the two members as equal or different, but just found the judgment breaking in on me."

Bo still clings in great part to his kinaesthetic comparisons. "After the second member, no judgment. Then a sort of muscular set to ring 'one,' together with the idea 'the second is always shorter' and the inhibition and subsequent rejection of this tentative judgment. Then a definite visual-kinaesthetic successive comparison. I imaged each and bent over to it, at least in kinaesthetic image. I think the degree of the bend was the duration. Then the idea of equality (visual and muscular) and the judgment;" "was interested most of the time in the apparent shifts of the lights and quite lost sight of my obligation to note duration. At the end of the second, however, I caught myself giving a very decided nod as if I were bending forward in time with the exposure. Then suddenly I became aware I was ringing; think the first thing I knew was the sound of the bell. Very quickly, with some kinaesthetic disturbance, I compared the two visually, i. e., a visual field with two bright figures of different extension, and concluded that the judgment should be less. Don't think the conclusion was anything but a muscular relaxation of the push-button hand after I had rung once." Although Bo gets more automatic in his judgments, he still uses visual and kinaesthetic reference often. "Whole business is quite automatic, and there's not much sense to the conscious side, i. e., meanings are not obvious in the content;" "Judgment followed the second member almost automatically. Immediately after the judgment, I thought that although the two members *felt* the

same length (i. e., kinaesthetic representation), the second had looked shorter." In partial explanation for the difference between Bo's limens and those for the other observers we find at the first "I haven't yet learned to set myself for duration only. The qualitative differences are still most important." All through the series Bo reports many times "after the second member, called them both up in visual (or visual-kinaesthetic) terms"; and it is doubtless the fact that the image of the first member is less accurate than that of the second, and so tends to be represented as longer than it really seemed at the time, combined with Bo's difficulty in getting away from the set to judge quality and intensity, that gives him the marked error in his results.

D at first reports the organic feels which he had in the early experiments: "The visual sensations themselves seem to play little or no part in the judgment. I mean that the visual sensations merely set up this internal set of sensations (breathing and throat) and it is from these that I actually get my notion of the length of time." But later, "The only conscious part of the judgment is the *expression* of the judgment. The judgment itself, while I'm certain of its dependence on these organic complexes, is not made consciously." "The lights have a duration in themselves, but the time, i. e., the different time-values, seems to be more or less in me; I add it on to the sensations by means of little kinaesthetic cues in my throat accompanied by a certain kind of breathing."

F: "The judgment is usually what I should call automatic. As soon as the second member is over, without thinking of what I'm doing, I go ahead and press the button." "I don't think you consciously expect the second light to last as long as the first, i. e., there is nothing conscious that represents that expectation at all; but if that second light, as in this case, simply doesn't stay there as a light as long as the first one did, then there's a reaction of your finger on the bell at once." "What strikes me is how tremendously automatic the whole thing is, even when you are set to introspect. The judgment is so automatic, you don't think about pressing the bell, but just press it, don't say 'greater,' etc., don't think them at all. Don't think about what's going to happen before it happens."

W reports practically nothing but "immediate" judgments. "Second member touched off the vocal-motor judgment 'longer';" "No secondary criteria that I could recognise; an immediate impression of longer; don't like to say it that way because the impression becomes conscious after the judgment is touched off. You just report 'longer,' and that's all." W often reports "I am taking the experiment naïvely."

In the experiments with auditory stimuli the sounds were reported to change "in quality or in intensity or both" during the course of the member. With visual stimuli, we find nothing of a pulsing as with tones, but we find changes in the quality or intensity of the members. Here again, we find that it is not necessary for an experience to be unchanging in quality and intensity in order to be taken as a single experience "going forward," or as a single experience "with a definite duration," or to be reported as having "its first part there in some sense when the last of it comes."

Bi: "Noticed a spreading out of the rays of light;" "saw a little light and this extended in diameter quite rapidly and then returned to its original size;" "another case of the light swelling up to a certain maximum and then immediately shrinking back again."

Bo: "The first member came in fairly intense, then was suddenly much brighter, and then got darker;" "the member got first light

gray, and then after a moment, bright yellow;" "first member got very much more intense, then decreased in intensity slightly."

D: "The light seems not to be there all of a sudden, but seems to open out from the little spot;" "both the members seemed to come on and go off slowly;" "difficult to describe how the light comes on and goes off. It seems to open out toward me."

F: "The members seem to grow from the center;" "there is a coming on, a spreading of the light, and then it doesn't stay quite the same, in quality I think, mostly;" "the disappearance phase seems to take a shorter time than the appearance phase."

W: "The light got more intensive as it continued;" "slight qualitative or intensive differences in the first light, it wasn't uniform throughout the exposure."

With this group of experiments, then, we have a decided lessening of the conscious processes. This decrease began with the very first group of experiments (which used two filled times under "active" instructions), was retarded or stopped with the comparison of empty and filled intervals under the first instructions, increased rapidly again under the instructions to be passive, and continues to increase (with the possible exception of Bo) with the use of visual stimuli. This does not mean, however, as it might seem to mean, that the mere "going-on" of the members is sufficient to give a judgment of the relative lengths of the members. On the contrary, many reports are found which indicate that, although there is a going-on to the tone itself, there is no measure of the amount of that going-on until other processes (usually kinaesthesis) are introduced. That the judgment may be made without the consciousness of these processes may mean merely that the nervous system has acquired a set for a certain reaction to a certain stimulus, or that the observer is not set for introspection, or to watch for such processes. The importance of kinaesthesis in the reports of the observers was so evident that it seemed profitable to take a series of experiments in which a sense-organ was stimulated which had no primary kinaesthetic sensations of its own (as the eye has eye-kinaesthesis, etc.), and the following experiments were therefore made.

Group 9

In this group of experiments the stimuli were continuous weak electric shocks (80-83 interruptions of the primary circuit per second) upon the arm. The same apparatus for regulating the length of the members was used as formerly; but a small induction coil connected with one cell was introduced into the circuit in the experimenter's room, while the observer had a large electrode on his neck, and a small electrode (consisting of the end of a screw filed smooth and even

with a strip of wood through which it was screwed, so that the observer could not tell any difference in pressure between the wood and the electrode) fastened on his arm. It was found necessary to spend about ten minutes at the beginning of the hour in preliminary work, to assure a "pins and needles" experience without any muscular contraction. The observer shifted the electrode on his arm till he found a position which gave no muscular contraction, and the experimenter varied the strength of the current until the observer reported "pins and needles." [46]

The instructions to the observers were similar to those in the preceding group. Only one standard (60°) was used.

TABLE 10

Electrical stimuli. Filled—filled. Ten cases. Second member the standard.

	S = 60°			
	Dl_1	h	Dl_u	h
Bi	9.8	.056	6.1	.069
Bo	16.5	.068	2.1	.043
D	23.0	.057	11.9	.052
F	10.1	.064	.4	.053
W	11.3	.052	.5	.042

This table shows a general agreement among the observers, although D has by far the largest equality-zone. The results show the same time-error that was evident in the work with visual stimuli and that, in fact, has appeared in all the work. It is, however, not safe to attempt any comparison between this table and any of the preceding tables except Table 9, on account of the change of instructions; and even a comparison

[46] It proved necessary each day to make the current comparatively strong at first, because at the beginning of the hour all observers were unable to feel a current which later was so strong as to be excessively unpleasant. When the observer had once felt the current (the first time it was felt it was usually felt as strong), the experimenter reduced the current to a very small amount and, after the observer had reported "pins and needles," the quantitative series were begun. It was occasionally necessary with observer D to reduce the current again about the middle of the hour; and although this procedure changed the conditions somewhat, it changed them less than if the observer had felt the current as steadily increasing in strength.

of Tables 9 and 10 may be misleading, unless it be remembered that all the observers had had more practice in the experiment when they came to Group 9.

The introspections are very similar to the previous introspections.

Bi: "This was one of the cases where in the second member the judgment occurs at that point which marks all the time before it as equal to the first member. Don't know how this point is located, but it seems that the second member has a double function. It exists in its own right as its own time, but it seems to carry along with it the time of the first member. The first member doesn't appear consciously alongside the second member at all." "I seemed to be conscious of only the second member, yet at a certain point in the second I knew what the judgment ought to be." "Attended carefully to the first member, but when it stopped, it disappeared from consciousness, there was no memory of it. I was thinking about a change in intensity in the second member, when this thought was displaced by hearing the sound of the bell, and the feel of my hand pushing the button. I knew what I rang, i. e., after the ringing was over, and felt satisfied with it." "I am just as conscious that the pricking lasts for a certain time as I am that it is a quality of pain." "Think the other factor beside a visual image this time in making the judgment was the absence in the second member of enough stimulus at the end to make it equal to the first member. This is pretty much a feeling. I have experienced much the same sort of thing when I go to a shelf to pick out a book. I am not particularly conscious that I expect to find the book there and yet I never doubt that it is there. Suddenly, now I put up my hand to take it, I find it isn't there at all. Now I seem to have an expectation set up by the first member, just exactly as my experience has made me know that a book is in a certain place. The stopping of the second member before it is equal to the first leaves me in practically the same kind of state. I think this state involves a catching of the breath, and a certain kinaesthetic set like speaking, only nothing is said."

In the case of Bo visual images and kinaesthesis are still prominent. "Judgment very easy. I was set to get durations only, i. e., didn't notice intensive, or qualitative or extensive changes, if there were any. Visualised both members as they were progressing. In the interval I saw the first member drawn out into a length which meant duration. Don't think either member got drawn out into visual extent which meant duration during its course, but there was something which *made* the two seem to have progression and I suspect that something was eye-movement. During the second there was some sort of reference to the first member, although I can't say just what it was, whether obscure visual imagery, or an eye-strain at the point where the first would have ended if laid along the second. The second was, however, somehow long absolutely and the judgment followed without any hesitation. Besides all this there was some sort of muscular aliveness in my arm which may have merely meant the localization of the stimulus, but which I suspect of referring in some way to duration." "The second member ran along very easily. I anticipated the point at which the first would have ended, and knew as soon as the second had gone beyond what the judgment was. Don't know what this anticipation is; all I can say is that I seem to be getting ready to make the judgment at some point in the second and then that suddenly my whole attitude

changes. I seem to see in imagery a point in the course of the second as a significant point. As soon as the second progresses by this point visually, my kinaesthetic attitude is one of relief and the judgment is made. The push of the button was almost automatic this time." "At the end of the second, slight hesitation, then visual comparison." "Absolutely no conscious reference to the judgment or comparison, or the necessity of getting the durational aspect clear until the end of the second. Then suddenly I'm ready to judge 'equal.' The visual imagery is *there*, but it wasn't as clear as the kinaesthetic attitude of decision, and the pushing of the button itself." "Second member was much like the first except that its end is anticipated. As the second approached the point where it should equal the first, I began to press with my finger. Feel sure I have done this before, too. I think what happens in such times is that the termination of the second touches off the ring automatically." Evidence that the variety of Bo's images really confused him in the judgment is given by one case in which the second member was really nearly twice as long as the first. Bo reports: "At the end of the second I simultaneously rang 'equal' and visualised the members as unequal, I reproduced them somehow in tactual-kinaesthetic terms which *seemed* equal, although the unequal visual images persisted."

D added little to his previous reports. "Each member is accompanied by a total feeling, muscular tenseness, general sensations of breathing, throat sensations. The first one holds over and runs along with the second, just how I'm not sure. The complex isn't identically repeated, but the general attitude that is set up carries over. Then that, of course, is affected by the complex which comes from the second member, and the resultant *means directly, is* the judgment."

F: "The judgments are not just as easy and just as immediate and automatic as they were with tones, perhaps a little less disturbing and easier than they were with lights." "I am certainly sure I don't know whether the strains and relaxations are cues to the judgment or not. Sometimes it seems to me that they are; sometimes it seems to me the course of the sensation is the cue; sometimes that little snaps of my eyes are cues (touch off the judgment); sometimes when I'm not analytic at all, I wouldn't be able to tell whether those things are there or not, or what touches it off. Surely sometimes the course may be identical and yet the judgment be 'longer' or 'shorter.' Sometimes I can't tell whether there are strains there or not, and still have a perfectly definite judgment." "I am convinced that changes in intensity and quality are not what I meant by course. What I mean by course is, I think, usually the increasing duration and the changes in the bodily attitude or feeling or the vague strain." "The members just ran their course separately, and there was an automatic judgment, an automatic pushing of the bell. Certainly there is *never* a recall of the first member in image or anything of that sort. There isn't a visual image of the members while they're there, either." "Just the two members there, one after the other, each in its wave of attention, and me in a duration-comparison attitude."

W: "The judgment is touched off immediately without any reference to imagery and without any effort to compare." "There was no attempt to compare the two, the judgment was given immediately." "The judgment this time was again a judgment of duration rather than of length of visual image, although the length was there. The clear thing was a 'going-on' of the stimulus, and the second didn't 'go on' as long as the first." "General attitude one of unconcern, yet

the judgment was touched off immediately and with certainty." "Judgment again touched off, that's all I can say, but with considerable uncertainty this time, though I can't for the life of me catch anything in consciousness except the deliberation, the wait; i. e., my thumb doesn't report at once. There is no thinking, no comparison, one simply doesn't report at once." "I don't think there was anything there but the duration." "The judgment 'almost equal' was touched off vocally before I rang the bell, and yet the bell rang 'shorter' and I was satisfied with the judgment. Your finger does go ahead and press the button, and then there's very apt to be a question raised after the report has been given as to whether or not it was correct."

The sensations on the arm were reported by all observers as unsteady.

Bi: "The first member was a sort of a line of pricks, as if a sewing-machine needle running very rapidly had been run for a certain short distance along the skin;" "there was a change of intensity in the second member."

Bo: "The experience splits up into parts. I visualise it often as a sand glass and as such it is as if the sand streamed first on one place, then shifted a little, then played on another area, etc., with various intensities of blast."

F: "It feels more or less like a trickle of sensation from the skin down into the tissue;" "have a tendency to express it that the sensation seems a little wavy;" "feels like a trickle of tiny drops going down in."

D: "Sensation seems to spread out in zigzag streaks;" "first member pulsated more than the second;" "member changed in intensity."

W: "It is much as if you were tapping very rapidly on my arm with a sharp pointed bristled brush."

These introspections did not bring out, as we hoped they would, the differentiation between a sense-organ which has its own kinaesthesis running along with its sensation and one that has not. One reason is evidently that the effect of practice in automatising the judgment, till it is scarcely more than a reaction, was more effective than the quality and the kinaesthetic accompaniments of the sensation. The observers seem to be arranged in a straight line as regards the number of mechanical or automatic judgments, ranging from W who gives these judgments almost without exception, through F, Bi, D, to Bo who reports them only a very few times.

Conclusion

In the course of our experiments we have found, in some guise or other, all of the secondary criteria of temporal judgments that have been reported by earlier investigators. We have found, for example, the breathing strains of Münsterberg,[47] the expectation and surprise of Schumann,[48] the bodily movements,[49] vague kinaesthesis,[50] visual imagery[51] and so on, of the other experimenters. No one of

[47] Pp. 15, 39, etc. [48] Pp. 10, 15, 20, etc. [49] Pp. 8, 11, etc.
[50] Pp. 8ff, 20, etc. [51] Pp. 9, 15, 19, etc.

these aids to the judgment has been found to be essential; for any one could be replaced by any other, although vague kinaesthesis[52] is almost always reported, and visual imagery is the aid to which all observers turn when in doubt. We have found, moreover, that there are times when the observers are unable to discover anything in consciousness as the basis of the judgment save the mere going-on of the members.[53] Such cases were particularly frequent when Meumann's instructions were given, but they were also found before the observers had received those instructions. The first instance is doubtless an example of automatization of the reaction consciousness. The second may be due to the Aufgabe concerned.[54] As we have said, the ability to discover secondary processes depends largely on the determination given by the instructions, and Meumann's instructions, which set the observer against a detailed analysis of consciousness, could not be expected to bring out reports of many secondary processes.

From the results concerning the mechanism of the temporal judgment, we may conclude that, at first, all observers voluntarily institute movements of the body (of the trunk, or head, or arm, etc.).[55] After a small amount of practice, these gross movements disappear;[56] and then all observers report slight, vague strains, usually localised in the organ stimulated, although sometimes making up a general bodily kinaesthesis.[57] Visual imagery is used as a reference in most cases of doubt.[58] Finally, with a large amount of practice, all observers tends toward (and some observers reach) an automatic, immediate judgment with no conscious basis save the bare sensation, itself.[59]

From the results concerning the character of duration, we may conclude that, under proper conditions, that is, when the observers are not under too strong a determination to make a *comparison* of times, we may approximate to a mere "going-on" of sensation which corresponds to the vague extendedness of the visual field of the closed eyes. Instances of this from the introspections of the observers may be requoted: Bi, "There is not much to be said about the tone. It merely seemed to exist for a certain time." "Don't remember much of the first member; nothing but a sort of impression that it had been presented for a certain time and was now over." "Very vague notion

[52] Pp. 9, etc. [53] Pp. 11, 16, etc. [54] Pp. 18, 32, etc. [55] Pp. 8, 9, etc. [56] Pp. 9, 20, etc. [57] Pp. 8, 15, 16, 20, etc. [58] Pp. 9, 14f, 20, etc. [59] Pp. 11, 16, 28, etc.

that the first member was rather short." Bo under passive instructions gives such reports as "No judgment at first, the two just did not seem comparable, not greater, not equal, nor less," "no judgment at all after the second member. I knew that both members were rather short absolutely. Completely baffled, however, as to the judgment." In spite of this lack of judgment, Bo constantly refers to the tones as "going on," as "having a temporal course." D, "I have no definite idea of how far apart the clicks were in time except the general notion that they weren't very near together." "The lights have a duration in themselves, but the time, i. e., the different time-values, seems to be more or less in me; I add it on to the sensation." F continually speaks of the members "going forward, going on, running a course." Like Bo he reports, "If you give yourself up passively you find yourself lost, no immediate judgment coming." W says, "Under the present *Aufgabe* [passive instructions] the feeling of necessity that I must make a very accurate report as regards the judgment is lacking, and the secondary criteria fall away, so that I seem to be left with nothing but the bare experience of going-on-ness."

We have evidence that the tones can be taken in either one of two ways. The duration may be either "static" or "moving," may be either length or progression. This conclusion agrees in the main with the distinction of Moede already quoted (p. 4) between duration and progression, and that of Meumann (p. 3) between succession and duration. The distinction becomes clearer if we refer to the statements of our observers, themselves. Bi: "When the tone had run its course, I seemed to have some sort of judgment of its length." "This time there seemed to be something passing before my eyes, much as if a fine dark thread were being drawn across the line of vision. The length of time during which this running along of the thread continued was the length of the tone. It seemed as if the tone were translated over into that visual form. I call this a line or thread because it is the best term I can think of. This thread, then, began to run before the field of vision at the beginning of the tone and continued to be brought along the whole time of the tone. The whole experience was about the same as if looking through a hole and watching a train go by. I put it this way to make it clear that the experience was not so that it could be observed *in toto* after it had passed, but had to be taken

just as it came." Bo distinguishes between "temporal course" [progression] and "duration" [length], by which he means "a sort of static, non-spatial extension. It is my notion of . . . the measure within a conscious present. It doesn't move along, although it may get bigger." D: "The tone seems to be a continuous thing; when you get to the end, you still have the first part." F: "The sound is all one thing; even though it has a course the sound is nevertheless in another sense all there at once." "Instead of apprehending the tone as a thing getting progressively longer, today I apprehend it as a unitary duration [length]." "You can take the tone as a *time* between its beginning and end, . . . or you can *follow* the tone, and as a matter of fact, you can take *both* these attitudes towards a single member, though not at once. . . . There is a difference between the time between two points and the time that goes on and you follow; the time that is extended, and the time that goes on." Gou speaks of a "fixing" of the duration of the first member. "There seemed to be a prolonging of the tone; this prolongation does not mean that the duration of the tone is made any longer, but just that I have hold of it, as it were." W: "When the tone was over, there was an effort to hold it." "I think of the member as being unrolled." "The first member seems to stand there in the interval." "These intervals somehow have a sort of unity." "Have a feeling that one *perceives* a duration in the same sense that one perceives a tree. It seems to be a unitary sort of thing."

Our results also point to the conclusion that all sensations have the inherent character of going-on or of progression. In this conclusion we agree with all those psychologists who give duration as an attribute of sensation. From the experimental work we may cite as examples of this position: Mach's earlier theory that all sensations are accompanied by the time sense; Vierordt's statement that the "spatial and temporal dimensions of sensory stimuli come, so to speak, immediately into our consciousness"; Nichols' conclusion that "duration is an attribute of every sensation"; and Meumann's presupposition that "the processes of our consciousness . . . are given constantly at the same time as processes of a temporal nature." From the psychologists whose concept of duration as an attribute of sensation is based less directly upon experimental evidence, we may cite Külpe, although we can not agree to the identification of physical and psychical time, and Titchener.

We come now to the question of the place of duration as an attribute. As we have already said, there are two ways of taking the temporal experience, as progression and as length. These stand at quite different levels, and are the results of quite different attitudes toward the experience. A sensation taken as it comes immediately to one, as it comes under a merely existential determination, progresses. The determination to compare or to estimate, however, tends to result in a taking of the experience as a length. Progression is the more ingrained, the more vital aspect of the experience; without progression, length is impossible. Length is something that may or may not be added on afterward and does not belong to the sensation as such. That is, the sensation has length only in retrospect, has length only after it is over, while it has progression while it is going on. In fact, the going-on *is* the progression, and by going-on we do not mean continuance in physical time, but the immediate experience of going-on. The length is, so to say, a "fixing," a "making static" of the progression for a simultaneous view. It is a consciousness which involves supposing that the first of the tone is still there in some sense when the last of it comes. Now, to obtain this view, the progression must be referred to something outside itself, it must be given a definite beginning. As progressive alone, the experience seems to have no beginning or end. It is related no more to beginning and to end than the field of the closed eyes is related to definite points, say the furthest we can see to right and left; it is mere going-on, that is all there is to it. Length, on the contrary, is most clearly expressed as temporal *distance* between two points. It is the result of a perceptual, rather than of an attributive attitude. We find, from our introspections, that it is more difficult to harden the progression into length at some times than it is at others. At such times the observers report that the member was so long that the first of it was gone before the last came. That is, it did not "compose a single perception," did not impress them "as unitary," "was not in a single wave" or "single span of attention," "was not contained within a single conscious present." For them, as we have seen, progression goes on within such a time, whereas in general the conscious present, taken as a whole, as a perceptual unitary thing, *is* itself length.[60]

[60] When Washburn (*loc.cit.*) maintains that the conscious present has no subjective duration, she is quite evidently thinking of duration not as progression, but as the simultaneous view of the experience which we have called length. That she can deny that *progression*

If, then we take duration in the sense of progression as an attribute (and duration in the sense of length as a percept),[61] there arises the question of the status of this progression attribute as compared with that of other attributes. It evidently does not hold the unique place of quality, but belongs with the quantitative attributes which furnish the basis for answers to the question "How much?" Just as extendedness is the basis for answers to "How far?" and intensiveness for "How much?", so progressiveness is the basis for the answers to "How long?" Of the intensive or quantitative attributes, extent seems most closely related to progression; both are vague extensions, continua, only the one is of space, the other of time. Progression is also more or less similar to the generally admitted attribute of intensity. Indeed, our observers sometimes say "it is like having some more of the same thing added on to it." We take it that you can "add more of the same thing" in three different ways: add to it beside itself, i. e., spatially; add to it after itself, i. e., temporally; add to it at the same place and the same time, i. e., intensively. Of these three, intensity is the only one admitted by all psychologists. Its enviable position is due, not to any superiority which it has over extent and progression, but to the fact that Fechner stated its position flatly, and others agreed to his decision without requiring introspective evidence. If, instead of this introduction, intensity had received the experimental treatment that has been accorded to duration, it too would have gone through the stages of being taken as a relation, and as a result of secondary criteria and mediate judgments, through which duration has passed. But in time we should have found, as we have found for duration taken as progression, an inherent aspect of sensation which we must call an attribute.

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takes place within this present seems hardly possible. If succession be taken as equivalent to progression, her statement that the "psychologically primitive time judgment is one of succession, not of duration" seems rather to bear out our own thesis that duration, in the meaning of progression, is an attribute of sensation.

[61] Distinctions like that between length and progression do not seem to us peculiar. Quality, extent, intensity, clearness, can all be taken in a similar way. Bare "thatness" is attributive; "redness" (as distinct from blueness or orangeness) is perceptual and involves a reference to other modes of "thatness" or to points on a scale of qualities. Bare "spread-out-ness" is attributive; size is perceptual. Bare "muchness" is attributive; "so loud" is perceptual. Bare "liveliness" is attributive; "so clear" is perceptual.

ON THE PSYCHOMOTOR MECHANISMS OF TYPEWRITING

By Frederic Lyman Wells,
McLean Hospital, Waverley, Massachusetts

"The record of the accuracy remains long after the speed is forgotten."

Typewriting is one of the most important industrial operations. To many persons it is the direct means of livelihood and other persons are continually undertaking its study with a view to making it such. There is perhaps no psychomotor process so directly open to experiment in which efficiency is of such wide practical value. Scientific inquiries into increasing the efficiency of typewriting on the psychological side may have a two-fold aim,

1st. To discover the symptoms which presage success or failure in acquiring the accomplishment, in order that the probable progress of the learner may be predicted, that he may be encouraged so far as possible in a career which promises good results for him, or dissuaded as soon as possible from wasting time in something in which there is practical evidence that he will not succeed.

2nd. To study the various conditions of efficiency in typewriting as affected by different times of day and different work periods, and different techniques of operation, etc., in order to increase so far as possible the efficiency of the skilled operator.

The present experiments were made to get a further insight into the means of attacking these questions and also as a practical introduction to the broad problem of studying psychomotor adaptations experimentally through the media of choice reactions.

Non-Experimental Observations.—Typewriting is in a special position in that it is possible not only to make measurements of performance in it experimentally, but also to compare these with fairly accurate observations under non-experimental conditions where the operator is unaware that the performance is being measured. Subsequent to the experiments, a few observations of this sort were undertaken in which the operators, both of whom are professionals of

years' practise, of course worked at their accustomed desks, and at their own machines, which are Remingtons. They did not write the same material but it was of the same sort, namely portions of clinical records. Intrinsically, one operator's copy may have been slightly more difficult than the other's, but on the other hand this operator is much more accustomed to this sort of copy than the other. Timing was with the stop watch, by pages, and the finished product was later examined for errors. Results are shown in the following table:

FASTER AND LESS ACCURATE OPERATOR

Observation	Number of Strokes in measurement	Average Strokes per second	Errors	
			Number	Per cent
Day I—*a*	374[1]	3.17	5	1.34±
b	1518	4.34	3	0.197
c	1466	4.14	3	0.204
d	1694	4.58	7	0.414
e	1613	4.48	9	0.559
Day II—*f*	1647	4.64	4	0.243
g	1466	3.44	10	0.681
h	1583	3.91	4	0.253
i	1611	4.74	9	0.559
Average experimental performance..	1581	5.27	11.9	0.753

SLOWER AND MORE ACCURATE OPERATOR

Day I—*a*	3507	3.88	5	0.142
b	3620	3.81	3	0.083
c	3545	3.21	4	0.113
Day II—*d*	3206	4.24	5	0.156
e	3338	3.62	2	0.060
f	856	3.86	1	0.117
Average experimental performance..	1413	4.71[2]	8.5	0.601

[1] At this point the operator removed the sheet and began the page afresh
[2] This operator shows some practise gain in the experiments, *cf* below.

In each operator, the non-experimental rate appears in general as nine-tenths of the experimental rate; but it is really somewhat closer to it than this because the non-experimental observations include stops for erasures and other pauses that are not wholly relevant to the measurement. The time for external interruptions, when they chanced to occur, was taken out. The experimental conditions cannot, according to the above, be said to have produced, as such, individual differences in speed foreign to the differences of ordinary performance. The case is quite otherwise with the errors, for while in the former operator the errors in the non-experimental observations are 55% of those under experimental conditions, in the latter operator they are but 18.6%, the latter operator making, in general, over five times as many errors with the experimental conditions as without them, the former

one only about twice as many. There was a noteworthy difference in the co-operativeness of the two operators in the experiments, to which this may be related.

The Experiments.—The machine used was a Remington Standard Typewriter No. 10. Contacts with platinum facings were so adjusted to the machine that one electric circuit was made whenever a key or the spacebar was struck, and another only when the spacebar was struck. These circuits operated signal magnets whose movements were recorded by ordinary graphic methods. The speed of the recording surface was approximately 12 mm. per second, the time intervals being marked by a Jaquet Chronograph.

The table and chair employed experimentally had been used for years in typewriting by both operators, though it was not being so used by them at the time of the experiments.

The experimental work by each operator consisted in writing for five minutes at the beginning of work, about 8.30 each morning, and for five minutes again at the conclusion of the morning's work period, about 12.00 m., for fifteen days. Both operators of course wrote the same copy on corresponding days. The copy was taken from Emerson's Essays, as a text free from dialogue or italics. This material is foreign to what the operators are regularly accustomed to (clinical records and business letters), being more involved and obscure, with a different vocabulary.

The external marginal stop was set so that the bell rang at 61, and the stop became effective at 69 on the scale.

The operators were not given verbal instructions, but typewritten ones, which were as follows for the first ten days:

> At the word "Go," copy the given text, beginning at the point marked with pencil, and continuing until the word is given to stop, as it will be after five minutes of writing. The lines of your writing will be single spaced. Write at your best working speed, that is, the speed by which you would wish your efficiency as an operator to be judged. Make no stops for corrections, make no strikeovers, and do not use the back-spacer.

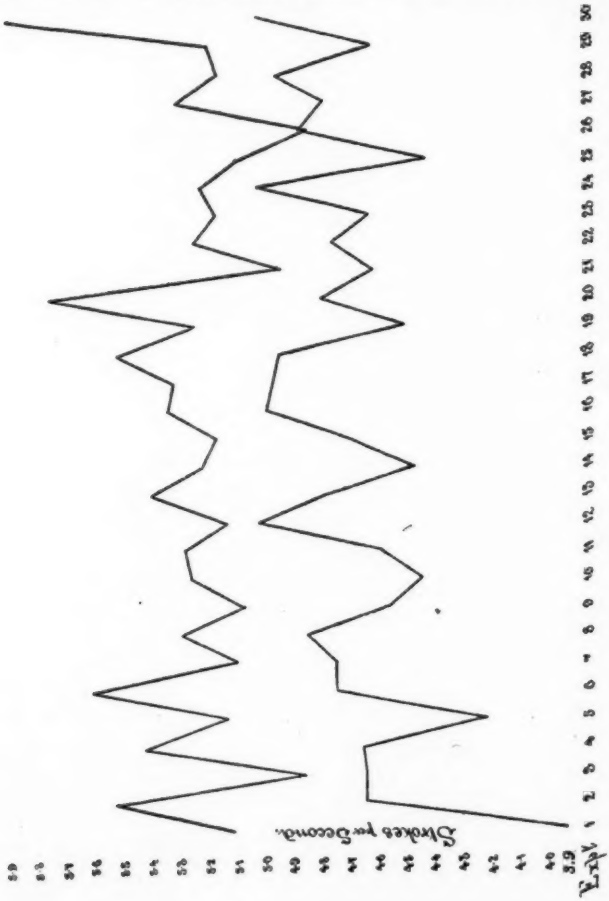
For the last five days the instructions were as follows:

> At the word "Go," copy the given text, beginning at the point marked with pencil, and continuing until the word is given to stop, as it will be after five minutes of writing. The lines of your writing will be single spaced. Aim to make no errors, and write at the best speed that will make this possible. Make no stops for corrections, but the back-spacer and strikeovers may be made use of at will.

The instructions should have been given in the reverse order from that here quoted; from this standpoint the procedure is not very sound.

The reaction of both operators to these instructions was to write at abnormally high rate for them, with a correspondingly large number of errors.

Elapsed Time of the Total Process.—This concerns the amount actually written in the 5 minutes—the ordinary practical measure of typewriting speed. It is usually stated in



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terms of " words per minute," but this means very different things according to the class of copy used, quite aside from its familiarity. More precision may be sought by measuring not the number of words but the number of *strokes*, that is, touches which result in a forward movement of the carriage. The space-bar is here counted as a stroke, though it is much quicker than the strokes of the keys. On the other hand, shifted keys also count as one stroke. This number of strokes is the absolute measure of the amount of typewriting done in the period; it is considerably affected by at least one other factor, the time of returning the carriage after each line. The question of accuracy is separately dealt with. The following curves give the average number of strokes per second, for each five minute period of writing in the thirty days' experiments, with the two operators.

Time of Separate Processes; the Carriage Return.—This is the longest single process involved in typewriting. With the present machine, it requires merely a backward sweep of the hand, against the proper lever. The average time per line consumed in this process was distributed as follows for the two operators:

Seconds....	.4	.5	.6	.7	.8	.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	Over 2.0
Records:																		
1-15....	1	..	27	61	69	32	28	12	15	15	4	11	1	1	6	1	1	7
15-30....	1	2	51	70	85	37	22	21	15	9	4	4	1	..	4	4	2	8

Records:																		
1-15....	1	..	..	..	..	1	14	42	52	55	49	29	21	9	15	2	3	.. 11
15-30....	..	..	..	..	..	1	7	31	49	95	50	42	14	14	5	8	5	.. 1

The general median time of the carriage return in the first quoted operator is .87, in the second quoted, 1.28 seconds.

Book's allowance of three strokes for the carriage return would therefore be too little for these operators. The carriage return takes the time for about five and a half correct strokes in the first operator and for about seven and one-third correct strokes in the second.

The methods habitually used by the two operators are not the same. One operator brought the thumb against the hook in the lever, and pushes it back with a single extensor movement of the arm; the other grasped the lever with the fingers, giving it a distinct twist. These latter motions result in a decrease of some 3% in total typewriting speed, not to mention the additional muscular strain put upon the arm.

Carriage Return in Paragraphed Lines.—Although the first lever of the column selector was set at 10, and the start of

every portion of copy was paragraphed to begin at this point, neither of the operators used the column selector for paragraphing, but returned the carriage by hand for the paragraphs also, making corrective movements (or not) with the space bar and back-spacer. One operator aimed to begin paragraphs at 10, but began them elsewhere, usually at 11, in 8 cases out of the total 36; the other aimed to begin paragraphs at 5, but began them elsewhere, regularly at 6, in 9 cases out of the total 30. When the next line begins a paragraph the time of the carriage return is distributed as follows in the two operators.

Seconds.....	.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	Over 2.0	Median
Operators...	1	3	1	5	3	7	3	..	..	..	..	2	4	1.43
	..	3	2	4	5	1	1	3	3	2	1	1	4	1.45

Carriage Return as Affected by the Marginal Release.—One of the operators made no use of the marginal release throughout the experiments. At the end of experiment XIII the other observed that it was set before the end of the line and during the succeeding experiments operated it in all 19 times. Apparently the fact of having been preceded by an operation of the marginal release makes the carriage return slower than it would otherwise have been by over 33%, as shown in the following distribution:

Seconds	.7	.8	.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	Over 2.0	Median
Operator...	1	1	3	2	3	4	1	1	..	..	..	1	..	..	2	1.17

Time of Operating the Marginal Release.—The time of operating the marginal release in the 19 cases mentioned above is between 1 second and 2.5 seconds, averaging 1.6 with an m. v. of .36 seconds.

It is thus apparent how the use of the marginal release cuts into the typewriting speed, not only by the time taken to operate it but by reducing the speed of the carriage return, so that the learner should be firmly trained to resort to the marginal release as little as possible.

The Back-spacer; Inhibition and Time for Operating.—Under the conditions it was not practicable for the operators to overcome the long-standing habit of using the back-spacer. One operator used the back-spacer 6 times during the days it was not supposed to be used, the other 69 times. The inhibition gradually improved, the uses of the back-spacer being distributed as follows through the successive experiments.

Experiment.....	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
No. of backspaces.	10	6	3	8	4	1	6	1	5	2	1	2	4	4	4	2	1	2	2	1

For the last 10 days the use of the back-spacer was part of the conditions of the experiment. The strikeovers were measured, giving the time lost through the necessity of operating the back-spacer. This is considerable, averaging about a second in each operator; a back-spaced strikeover thus takes as much time as five or six correct strokes.

Average Time of Strokes in Errorless Typewriting.—This comes as closely as possible to the actual speed of the typewriting process uncomplicated with extraneous factors such as the carriage return, the back-spacer, etc. As a more or less arbitrary determinant is taken the time required for three errorless lines in each record that contain the least evidences of blocking. The time for writing the lines is divided by the number of strokes in them giving the average time for each stroke. No statement of variability can be given for individual strokes. The results for the successive 30 experiments are as follows in the two operators: (See cut, p. 54.)

These figures must not be thought of as true reaction times. These it is impossible to obtain because the instant of stimulation cannot be fixed. They are shorter than most elementary choice reaction processes, indicating a large amount of overlapping, of which indeed one seems to be introspectively aware.

Steadiness of Typewriting Rate.—The method employed does not lend itself to precise measurement of the variations between the individual strokes. If the experiments were being repeated more attention would be paid to this. Instructions to learners lay some stress on the value of sacrificing speed to steadiness, and psychology has seen in the mean variation a criterion of attentional control. The difficulty in the way is that the rate in writing any material is very dependent on the familiarity of it to the subject and of course the same material is not equally familiar to different subjects any more than it is in shorthand. At the beginning of typewriting practise this difficulty would not be so serious, and a good measure of steadiness of writing rate will be an important factor in predicting the future efficiency of learners.

Book calls attention to the presence of various important processes in typewriting, of a more strictly mental nature, which do not show in the learning curves. If this means that an accurate control of introspection is necessary for the prediction of future efficiency in the learner the practical value

Inches of Rain
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Inches of Rain per Fortnight Stroke.
8 7 6 5 4 3 2 1 0

of typewriting measurements will indeed be seriously limited in this direction. But it is doubtful if the actual conditions of learning have yet been closely enough studied, with the following up of the future efficiency of such learners, to warrant pessimistic conclusions.

Relation of Speed to Accuracy.—Of course we know that in general practise improves both speed and accuracy in typewriting; the novice writes slower and makes more mistakes than the expert. Between individuals a broad positive correlation thus obtains between speed and accuracy that need not be confirmed experimentally. On the other hand, if an individual speeds above his optimal rate, more errors are produced, and the same is the case if he tries to write slower. In these experiments the slower writer also makes the fewer errors. A more legitimate question is whether, on days when a highly practised subject writes faster, he also tends to write more accurately or not. In calculating this for the present operators the first ten records were excluded on account of their showing, at least in one operator, too much indication of practise.

The measure of accuracy is here the number of *errors* made in the five minute period. The measure of speed is the average time per stroke for the five minute period.

For the last 20 days the Pearson coefficient of correlation between the given measures of speed and accuracy were .44 for one operator, and .54 for the other. This is in line with the general findings in other psychological functions; increased speed and accuracy go hand in hand, "more haste less speed." It is not conclusive however, since the material necessarily varies in difficulty from day to day and an easy passage is of course written more accurately and faster than a difficult one. Then too, errors tend to retard the rate through the blocking which the consciousness of them produces. The best approach to the matter is by comparison of the rate of false strokes with that for correct ones, and this we are not in a position to do here. Very trustworthy data of a similar nature have however been obtained by Henmon, who has kindly put the material[1] at my disposal for the purposes of this study.

In central tendency, false reactions are regularly shorter than correct ones, but the differences are not so great as to raise the question of essential prematurity in their production, save for Subject S. in the experiments on lines. Often they

[1] Henmon: On the Time of Perception as a Measure of Differences in Sensations. *Archives of Philosophy, Psychology and Scientific Methods*, No. 8, 1906.

are very much longer and they are, as would be expected, quite variable. Since nearly every false reaction has an even chance of being superficially "correct" there are doubtless many more of them than come to light statistically. A subject may direct from his own introspection that a certain reaction be discarded even though the correct movement has been made. Though it is not by any means so regular as with the correct reactions, the false reactions show the same general tendency to become longer as the difference between the stimuli to be discriminated becomes less.

Number of Errors and False Strokes.—The process of typewriting from copy involves a great number of fairly complicated psychomotor adjustments following upon each other in rapid succession. These adjustments do not always run smoothly, but on various occasions incorrect and false adjustments occur. These false adjustments result in "errors;" their effects are seen in false strokes upon the machine making imperfections of the transcript. Two points of view are possible in considering the mistakes. From the immediate objective standpoint it is the "false strokes" alone that count, the more false strokes the worse the copy, but from a psychological standpoint it is plain that circumstances may arise in which a single faulty mental reaction may result in an indefinite number of false strokes. When ***admiration*** is read and written ***ambition*** the number of false strokes is a number equal to the letters in the word wrongly written, and yet there is only one real psychomotor "error." Most errors involving more than two false strokes are of this kind, that is, due to misreading the copy. Thus,

1. A *false stroke* is any stroke followed by a forward movement of the carriage which requires correction in order to produce a perfect copy.

2. An *error* is a faulty psychomotor adjustment resulting in the occurrence of one or more false strokes.

The actual number of errors in the records together with the false strokes they involve is as follows in these experiments:

Exp.	No. of errors	Operator: No. of false strokes they involve 1	2	3	Over 3	Total false strokes	No. of errors	Operator: No. of false strokes they involve 1	2	3	Over 3	Total false strokes
1	20	17	2	..	(38)	59	20	17	2	1	..	24
2	13	12	1	..	..	14	15	13	2	..	..	17
3	5	4	1	..	..	6	12	12	..	..	..	12
4	11	11	..	..	..	11	10	9	1	..	..	11
5	12	9	1	1	(7)	21	8	7	1	..	..	9
6	12	8	2	1	(47)	62	14	12	1	1	..	17
7	19	16	2	1	..	23	13	11	1	..	(10)	23
8	9	8	1	..	..	10	6	6	..	..	..	6
9	10	5	2	3	..	18	17	15	2	..	..	19
10	4	4	..	..	..	4	10	10	..	..	..	10
11	5	3	1	..	(36)	41	11	8	1	1	(39)	52
12	3	2	1	..	..	4	21	19	1	1	..	24
13	8	7	1	..	..	9	12	11	1	..	..	13
14	15	13	..	2	..	19	14	13	1	..	..	15
15	5	5	..	..	..	5	14	13	1	..	..	15
16	5	5	..	..	..	5	13	10	3	..	..	16
17	4	2	1	1	..	7	13	12	1	..	..	14
18	8	7	1	..	..	9	11	6	4	..	(10)	24
19	12	8	1	..	(8), (43)	61	19	17	1	1	..	22
20	8	7	1	..	..	9	7	7	..	..	..	7
21	11	11	..	..	..	11	9	7	2	..	..	11
22	6	6	..	..	..	6	12	10	..	1	(43)	56
23	6	6	..	..	..	6	11	9	2	..	..	13
24	7	7	..	..	..	7	10	9	..	1	..	12
25	7	6	..	..	(78)	84	13	10	2	1	..	17
26	7	5	1	..	(8)	15	13	12	..	1	..	15
27	7	7	..	..	..	7	9	5	3	1	..	14
28	5	5	..	..	..	5	10	10	..	..	..	10
29	8	8	..	..	..	8	6	5	..	1	..	7
30	4	4	..	..	..	4	3	2	..	1	..	4
Av.	8.5				Total	550	11.8					509
M.V.	3.5						3.0					

By far the greatest number of errors involves only one false stroke; that is, they represent simply the striking of one wrong key, after which the writing proceeds correctly. Those involving two false strokes are nearly all transpositions. Errors of more than two false strokes, including many with excessive numbers of false strokes, are practically all misperceptions of the copy.

Kinds of Errors, Different Psychic Levels that they Represent.—An error is the product of interference with the normal adjustive processes from somewhere. The error of writing

admiration for *ambition* is obviously a very different sort of error from that of writing *amvition* for *ambition* and one much more serious in its effects upon the copy, just as the despatch of false orders on the battlefield is more costly than the blunder of an individual soldier. Originating as they do quite outside of and not involving any defect in motor adjustments they may be thought of as errors of the highest level type.

Superficially there is a distinct line of cleavage between the uncommon, but far reaching errors of this sort, and the ordinary mistakes which are simply substitution, transposition or addition of a stroke or two. Three questions present themselves in regard to these very transitory breakups in the adjustments. First their relation to consciousness, second their relation to the time of the immediate and surrounding processes and third their relation to the content of the copy surrounding them.

On the first little is to be said here, indeed the conditions inherent in the normal typewriting process are prohibitive of immediate introspection. It is doubtful if much more can be done with this feature than Book has already done. There may or may not be consciousness of having made an error. The faulty ideomotor processes that are expressed in the error may or may not be present in consciousness before the error occurs. More regularly however it is the actual making of the false stroke that brings the process into consciousness, at least so far as insight into its falsity is concerned. Sometimes the idea of falsity (whether conscious or not we have no means of knowing) seems to come before the stroke is completed so that the key while wrongly struck leaves an impression lighter than the normal. As under the conditions of typewriting the memory of all conscious process must very quickly fade, one can seldom be even half sure of how much in any given process has been conscious.

One reaches firmer ground in the time relation of the errors. Where an error involves a block in the typewriting process at all, which it does not necessarily do, its most frequent position, in the data examined, is directly after the false stroke. Sometimes it does not come for another stroke and again it may come a stroke before. Occasionally too, there is a slowing of the writing process for some strokes before the error, indicating a gradual failure of the adjustments, though we do not know its relation to consciousness. The length of these blocks is seldom over 1½ seconds. Through the unfortunate mistake of trying to eliminate the

use of the back-spacer the interpretation of these blocks is not clear. The writer believes that they represent essentially the inhibition of the tendency to use the back-spacer the instant there is awareness of a false stroke, and that the back-spacer is struck nearly, if not quite, as promptly after the false stroke as the next key would be after a correct one. The indication is certainly that false strokes sometimes occur with insight into them and sometimes not.

What lies back of the failures of attentional control that show themselves in the errors is unfortunately beyond the scope of this study. What stroke is falsely made may be governed by quite deep-lying sources, and from the immediate surroundings of the copy, and from certain motor habits formed in typewriting common words, as will be illustrated.

It should be noted that the false strokes are generally effective strokes at wrong keys; inaccurate fumbling strokes at right keys play an insignificant part. During the entire gathering of the material no instance is recalled of two keys struck simultaneously so as to lock them.

The errors fall naturally into four sorts,—omissions, substitutions, transpositions (metatheses) and additions.

Their material will be presented in this order. It is most probable however that similar psychic mechanisms may result in any of these errors, what kind of error results depending mostly on the precise point of time at which normal control over the whole process is restored.

In quoting examples of the errors, it is not practicable to reproduce their smoked paper records, but it is usually desirable to indicate some features of them diagrammatically, i. e., slowness in writing rate, the place of occurrence of a block and its length. The scheme is adopted of leading the letters in the word where the writing is obviously slow, and indicating blocks by a row of periods inserted where the blocks come on the record, and indicating at this point the length of the block, thus,

Error	Correct Form
f a m i k$\overset{1.4\text{ s}}{\ldots\ldots}$iarity	familiarity

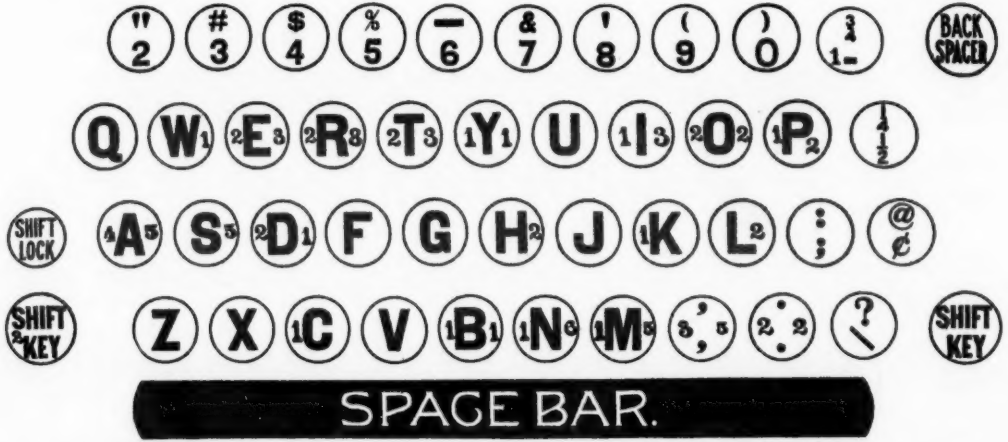
would mean that after a period of slow writing of the word up to this point, *k* was erroneously written for *l* and that immediately afterwards a block of about 1.4 seconds ensued after which the writing was again taken up normally. This scheme, supplemented by remarks, is used in representing nearly all the errors quoted.

Omissions.—An error of omission in the transcript results whenever the psychomotor process for striking the given key is not sufficiently effective to produce the legible impression of that key. A key may be struck too lightly to make a legible impression and yet strongly enough to trip the carriage. It is possible and even probable that many of these cases are abortive false strokes but there is no means of knowing this. In one of the operators there were 36 cases in which the carriage moved forward without a legible impression of the key struck. In the other the number cannot be arrived at, but the number of back-spaces observed is often greater than the number of strikeovers, which excess probably represents the correction of omissions of this kind. The cases in which the carriage did not move forward are illustrated as follows, the numerals lettered on the chart indicating the number of times each stroke of the given key was omitted by each operator.

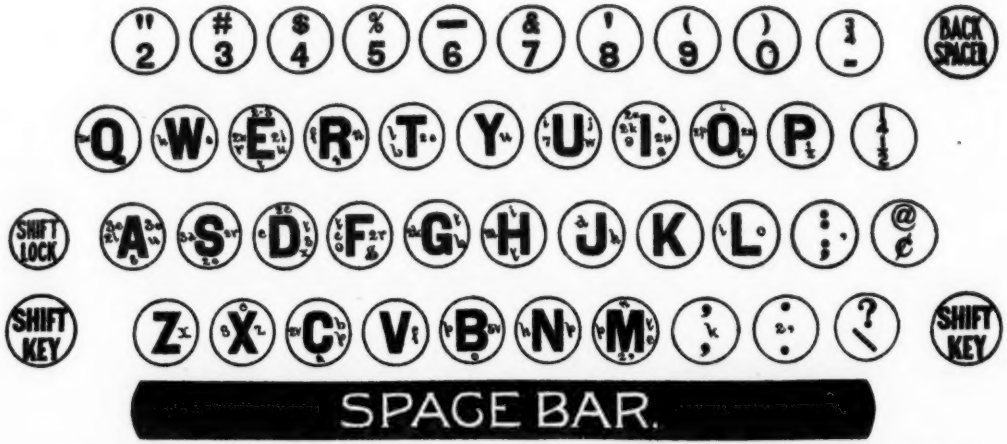
Certain keys seem to be subject to omission out of proportion to the number of times their strokes occur, but it is not possible to make further interpretation of this; *m* and *n* seem relatively difficult to reach. Operator J shows many more of these omissions than operator T does and they are chiefly distributed among the keys *a*, *s*, *r*, *m*, and *n*. The letter *a* is that most frequently omitted by operator T. The letter *e*, by far the most frequent of all, is not especially subject to this or any other sort of error.

Substitutions, Transpositions, etc.—The substitutions are illustrated in the accompanying chart. Here again the number of errors on a given key may be out of proportion to the frequency with which its stroke occurs. The two operators also differ in this respect. Operator T has many errors on *m* and *n*. Operator J shows distinctly more errors on *m*, though *n* is the more frequent letter. The kinds of errors also differ. Operator T shows evident cases of tending to substitute one particular stroke for another, as *j* for *h*, *z* for *x* and the comma for *m*. The errors of Operator J are more scattered except that *v* is often struck for *b*. In the errors made on *a* operator T substituted mostly neighboring letters. Operator J writes other vowels without regard to their proximity.

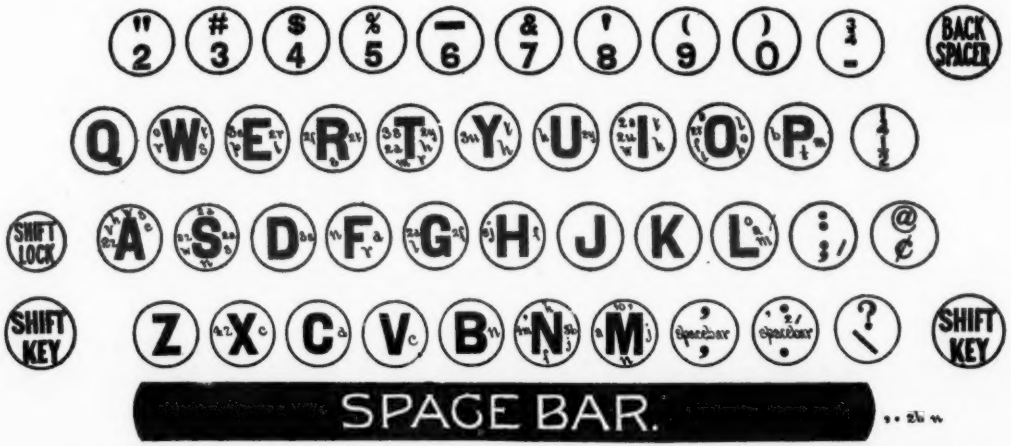
When neighboring letters are struck one is unable to know what is psychologically a very important thing, namely if the finger simply "dropped" off the key or if a wrong finger was used. It is certain that errors of both kinds occur.



Omissions by the two operators. A figure on the left of the letter indicates the number of times that letter was omitted by operator T, on the right, by operator J. Thus *e* was omitted twice by operator T, three times by operator J.



Substitutions by operator J. The large letters indicate the key which should have been struck; the small letters indicate the key which was erroneously struck. Thus *g* was twice written *k*, once *t*, and once *b*.



Substitutions by operator T. The large letters indicate the key which should have been struck; the small letters indicate the key which was erroneously struck. Thus *e* was three times written *s*, twice *r*, once *p*, and once *i*.

False strokes may result from the finger striking on a wrong bank of keys or being out of lateral adjustment, or the stroke may be in the corresponding position of the other hand, as the interchange of *e* and *i;* this is rare in the present material though a recognized type of error non-experimentally. The false stroke may also occur through a different finger with a different hand, as *n* for *r*, *w* for *u*, *e* for *m*.

There are doubtless errors which are determined essentially by the hands momentarily getting out of position through fatigue or some distraction. This however could produce only false strokes on neighboring keys and the fact that the false strokes are not in general "inaccurate" in a motor sense speaks further against this determinant as being of general importance. When a distant key is struck, as above, and with another hand, there must be a positive determinant for this particular key and it seems that the same factors at work here operate also, and more strongly, in the case of neighboring keys. It seems therefore that we should not speak of two types of errors, i. e., on neighboring and distant keys, but rather of two factors in the production of errors, one of which effects a mere dropping of the hands out of alignment and the other directs them positively towards a definite false stroke. These are not mutually exclusive but reinforce each other. Thus, a frequent type of error is the anticipation of a stroke really occurring later in the word and this seems to occur more easily if the anticipated stroke is in proximity to the stroke it replaces. Two typical cases are,

Error	Correct Form
mu$\overset{1.0\,s}{\ldots\ldots}$mor	humor
t r u$\overset{.9\,s}{\ldots\ldots}$u m phs[2]	triumphs

The mental process of anticipation is then more likely to express itself in a false stroke—that is, the factors of proximity and "distraction" reinforce each other in determining the false stroke.

In connection with these anticipations, or as they are called by students of linguistics, "regressive assimilations," and the transpositions or "metatheses," as they are technically known, a quite interesting finding appears. To quote from some analogous studies of the errors of speech and writing movements:

[2] In this error a motor habit "tru" may also be effective. *"Überdeterminierung"* looms large in the mechanism of these errors.

"It will[3] be noted that very generally in the regressive lapses of Meringer and Mayer, and almost invariably in both the phonetic and graphic material of Bawden, the error is discovered, or, at least, so indicated, before the proper place of the erroneously made movement is reached. This is also universally the case with the writer's graphic material; the error is discovered before the proper place of the assimilated letter is reached by the pen. This fact opens to serious question the nature of the regressive assimilation. . . . Suppose the subject is to write *Engadin*. He writes *End;* now if he were to go on normally and write *Endadin*, there might exist a true regressive assimilation. But of this there are almost no instances. In practically all cases in which the error is not discovered before the proper place of the assimilated movement is reached the word appears as *Endagin*, a metathesis. It is probable therefore that most if not all regressive assimilations are really abortive metatheses, in which the error was discovered, or the primary memory of it lost, before the arrival of the second member. Something of the sort is indicated in those lapses quoted by Meringer and Mayer in which the speaker's introspection gives evidence that the apparent regressive assimilation would have been a metathesis if the error had not entered consciousness. Thus, *'"Ich werde auf das Ei . . . auf das Kreuz vereidigt"* (p. 35). Unkorrigiert hätte der Fehler so ausfallen können; *"Ich werde auf das Eiz verkreudigt."'* And again, *'"Griebes . . . Liebesgram"* (p. 37); Ich glaube, ich wollte sagen *Griebeslam.'* This is one of the very rare instances in which the affected portions are not of the same extensity.

"The second member should therefore be considered as having, as such, no part or lot in the lapse. It will be noted that in most instances of the graphic metathesis, the affected elements are closer together than in the regressive assimilations, the relative separation of the movements in the latter being probably related to the greater time given for discovery of the error and change in the focus of consciousness. It will be noted that this latter condition is all that is needed to abort the metathesis, and that this may take place without consciousness of the error. The corollary of the non-existence of the regressive assimilation, save superficially, would seem to be obvious. If a certain movement is erroneously anticipated, that movement is not made again so long as the primary memory of it persists; a fresh start must be had, so to speak, the focus of consciousness must change, before the movement may be again attended to.

"There is, in fact, no case of motor metathesis which is not, in this sense, a progressive dissimilation, the second member being erroneously placed because of a consciousness of the individual movement-complexes, their number and identity, stronger than the consciousness of their order. When having made a linguistic movement prematurely we arrive at that space in consciousness which it should naturally fill, there is involuntarily substituted the movement that it displaced."

An examination of the present material confirms the above by affording an objective record of the temporal block between the two processes. If a stroke is written anticipatorily, that stroke is not made at the point from which it was anticipated

[3] Wells, Linguistic Lapses, *Archives of Phil., Psych. and Sci. Methods*, No. 6, 1906, pp. 86, ff.

without a definite block in the writing process somewhere preceding it. The cases which bear on this point are (in addition to *mumor* and *truumphs* above),

Error	Correct Form
(sp)..leas.....s	leads
i..t.....f it	if it
m....icrosp...opic	microscopic
gi.....ittering	glittering
tie.....e	time
ecu.....cation	education
int i.....itions	intuitions
o.....r.....om	from
co.....mestication	domestication
ornat.....ent	ornament
idt.....enti....ty	identity
w.....awakening	awakening
greath....(sp).....depth	great depth
indivud.....ual	individual
antu.....quity	antiquity
ah....other	another
(sp)....gun.....gus	fungus

Exceptional cases are:

Error	Correct Form
Jusus	Jesus
essentiam man	essential man
Imagintation	Imagination
they eyes	the eyes

If no block is shown on the smoked paper record then the regular result is a transposition. Accordingly most transpositions run off without blocks before or within the transposition, the cases on this point being as follows:

Error	Correct Form
exist,s	exists,
ture	true
parise	praise
happne	happen
raod	road

T h e b ias	Thebais
Brahim	Brahmin
(sp) t r y (2.0 s) ....(tyrranized, cf. below, p. 69	tyrannized
(sp) k ind g (1.2 s) .....om	kingdom
sia (.6 s) .....d	said
infel (.3 s) ...x-	inflex- (ibility)
real (.8 s) .....tion	relation

But a block may occur between the transposed letters, and yet a wrong letter be written in transposition as shown in the following:

Error	Correct Form
hod (1.0 s) l	hold
alr (1.2 s) .....am....(sp)	alarm
las (1.4 s) .....w	laws
pr (1.6 s) .....eform	perform
is (.8 s) .....t	its

Transpositions occur between strokes of different fingers of different hands, of different fingers of the same hand and even of the same finger of the same hand. They are usually between adjacent strokes (*prosperiteis*), but not necessarily so, (*proterpy*). Nearly always they represent the interchange of two individual strokes. The writer has observed, not experimentally, but one instance (*unpredijuced*) where the patterns of two strokes are interchanged.

In speech and writing there are instances where a sound or letter is taken out of its correct place and put somewhere else, *amen* for *mean* and *sanct* (.6 s) .....*urya* (1.2 s) ..... (.) for *sanctuary*. The only other apparent instance of this in the present material occurs in the only word that itself shows a peculiar tendency to be written wrongly, *virtue*, the mistakes made in writing this being as follows:

Error	Correct Form
virtu (.6 s) .....r (.6 s) .....(sp)	virtue
viture	"
(sp) virtur	"
vitu (2.5 s) .....e	"
vitures	virtues

The essential thing about these errors is the tendency to write *ture* which, as a common suffix, is probably a motor habit phenomenon. But observe that the misplacing of the *r* tends to eliminate it where it rightly belongs.

The mechanism of this whole process would seem to be the motor phase of the "inhibition of similars" investigated and discussed principally by Ranschburg, on the sensory side. It is doubtful if it has produced actual "dissimilation" elsewhere in the present material, for the following instances, though showing it superficially, may be mere omissions with which the recurrence of the same stroke in the word had nothing to do.

Error	Correct Form
remined	reminded
no e	none
creatues	creatures
Jesur	Jesus } (substitutions)
no toce	notice }

There is one case however that seems scarcely explicable on this ground,

Error	Correct Form
consit.....tu....ional.....ly (1.0 s, .5 s, 1.0 s)	constitutionally

It is tantalizing to have to quote such a case without its introspective data, and the interpretation is ventured that the second *t* is put in because *t* was omitted where it should first have come and that the cause for the omission of the last *t* is intimately dependent on the superfluous one inserted two strokes before. The subject writing above expresses a sense of motor pattern for words in typewriting, thus, "I spell the word mentally, but the fingers travel faster than I can spell it. Sometimes I get through before the mind is through and come out one letter short." This gives a probable clue to the nature of some transpositions, the omitted letter most naturally stepping in to complete the number of strokes felt to be the proper one for the word. This seems most likely in such cases, as given above, where the last two letters are transposed.

Allusion has been made to cases where the error is not concerned with the substitution or transposition of the ideomotor processes for the strokes as such, but with some particular function of them, as where the doubling is transposed in *voicelles*. The present material shows cases of this in *tyrranized* and *morrally*, thus:

Error	Correct Form
(sp) o r r (1.0 s) . . . . . a l l y	morally
(sp) . . . . . (2.0 s) t y . . . . . (.3 s) r . . . (.3 s) ranized	tyrannized
thses	these
(sp) T u . . . . (.8 s) nker	Thinker

That the former at least is not an error of spelling is indicated by the circumstance that immediately before this error the word has been begun with the three strokes *try*, after which the operator went back and started the word over again. A more complex form of the same mechanism is seen in *thses* for *these*. This error involved no blocks, in fact it and the surrounding material were written at unusually high speed. Fusion appears involved in the case of *Tunker* for *Thinker*, the *u*-key occupying a position between *h* and *i* on the key board.

Mention has been made of errors apparently resulting from the motor habits of writing words more frequent to the operators. Instances of this are as follows:

Error	Correct Form
startin g	startling
the . . . . . (2.0 s) t	that
s p e c . . . t a b . . . . . (.4 s) (1.2 s) l e	spectacle
powe . . . t . . . ' . . . s (.6 s) (.3 s) (.4 s)	poet's
powet	poet

Insertions of superfluous strokes (additions), where they are not assimilations from the context appear to be generally produced in this way, e. g., *repulsiong, meantimes, wisdome, either* (for *ether*).

Three cases are worth quoting as illustrations of somewhat severer breakups in the adjustments. In writing the word *obedience* the operator first writes slowly *obec*, then back-spaces once and writes *dic*, then back-spaces again and writes *ecn*. Whether this last would have been corrected cannot be told as the writing period ended here and the operator was stopped. Characteristic is the irrepressible breaking through of the *c* before its time. The whole process goes on more slowly than the usual rate of writing.

For *the*, the strokes *fht* were written. They were not blocked, but somewhat slowed and the next word shows considerable delay between the strokes.

For *own* the strokes *ouw* were written as follows:

Error	Correct Form
.5 s .4 s 2.0 s ou.....w....(sp).....heaven	own heaven

Probably the *u* is a motor habit error (*our*) and the *w* is a belated correction, the *n* being kept out by the "pattern" sense of the number of strokes in the word. Immediately after *w* there was a block of .4 seconds before the space bar was struck and then a block of two seconds before the next word "*heaven*" was begun. There was no back-spacing although in this experiment the directions were not against it.

There was no noteworthy individual difference in the kind of errors made except that there are four times as many transpositions in operator J as in operator T. Only the study of further subjects could show if this fact was in some way inherent in different methods of writing used by each. With both operators substitutions are by far the most common, omissions next, additions next and transpositions rarest.

Practical conclusions may be stated as follows:

The experimental conditions caused in both operators a more rapid and less accurate writing than normal for them.

Under the non-experimental conditions both operators wrote at about 9/10 of the speed shown under experimental conditions; one operator made about half as many errors under non-experimental conditions; the other about 1/5 as many.

In the experiments both speed and accuracy average better at the noon period than at the morning one.

An unusual amount of work during the morning makes the noon efficiency lower in both speed and accuracy; it has a more deleterious effect on the accuracy than on the speed. The general gain in efficiency from morning to noon does not appear to be dependent on the doing of typewriting in the meantime.

It is reasonable to expect from these results that typewriting will be in all respects better done towards noon than at the beginning of the working day.

SOME DEVELOPMENTAL PSYCHOLOGY IN LOWER ANIMALS AND IN MAN AND ITS CONTRIBUTION TO CERTAIN THEORIES OF ADULT MENTAL TESTS

By WALTER B. SWIFT, M. D., Boston

Before coming to the main body of this paper it may be well to review some unfamiliar facts of experimental psychology upon which I intend to base my theoretical superstructure. In this review I shall first present some data gathered from observation of dogs under training. Secondly, I shall describe some of the effects of vocal drill upon stuttering children. Next I shall record some of the steps in mental growth taken by a feeble-minded person who has long been under training for a defect of speech. Finally, I shall present some anatomical, neurological and neuropathological data collected in study of adult mental life, considered in a purely developmental aspect. Using these facts as a foundation, I intend to evolve from them several theories which they can be shown to warrant, suggest or imply.

1. *Center Development in Dogs.* Nine dogs were put under a uniform method of systematic training designed to teach them to differentiate between two tones. The process was as follows: The dogs were placed before a dish containing meat and then two notes were sounded—a low note and a high note. They were allowed to eat the meat at the sound of the low note but were punished for eating it when the high note was sounded. The training was continued until they developed the power to distinguish the two notes. They were trained three times a day for periods of about fifteen minutes and with the following results: At first they snapped up the meat without any regard to the two notes or to the punishment, but in a few days they began to show some hesitation after the sounding of the high note. This hesitation increased gradually until a fairly correct and constant reaction to the two tones had been developed. The time required for this development is important. On an average, it took fourteen days for the perfected reaction to occur with any uniformity.

We have here a condition reflex which, through severe

experience or punishment and regular daily drill developed in two weeks into a firmly established reflex that differentiated tone.

Just what is this and how should it be interpreted? Some may consider it only a simple, low-type reflex similar to the knee jerk in human beings and other analogous reflexes well known to all. The characteristic of these reflexes is that they follow immediately after a sensory stimulation that is taken up on the afferent side of the nervous system, sent across the cord as rapidly as such impulses can traverse it and is expressed externally in a motion corresponding more or less closely to the level of the stimulus. It seems to me that these characteristics are quite different from those of our above-mentioned condition reflex. In the distinguishing between the two tones there was surely sensory intake, a crossing over of that impression to a motor area and an external expression in the attempt to eat. Thus we have stimulus, conduction and motor action, elements which are all found, to be sure, in the simple knee jerk, but we also have another element which is shown in a pause made by the dog long enough for him to distinguish between the two tones and to act according to the distinction made. Here, then, we have a holding up of the motor expression pending the result of a rather complicated mental differentiation, whereas, in the simpler reflex, we have merely an immediate response.

In this reaction, then, there is added a collaborative control. That is, there is an idea of differentiation that holds up the expression of the stimulus until the differentiation can be made.

This differentiation must be localized higher in the nervous system than mere sensory intake and output. For it is a developed function not exercised before; it can be retained in the memory for months after its attainment; its function is different from the functions of the lower centers. Choosing words general enough to cover the field of these data and their logical implications without inspiring criticism, I think I may claim that a new function or a new condition reflex has been set up, or I might say that a new form of activity has been developed which controls, through delay and direction, certain motor acts. In two weeks a functional center has been developed which controls, by interpretation of a sensory stimulus and by guiding a motor output, a certain developed reflex.

2. *Training the Stutterer.* We come next to a consideration of somewhat similar methods employed in treating a severe speech defect in man. The development in man is in many

ways like that which has been noted in dogs, but we shall have to note certain points of difference which will serve our present purpose better than data gathered from observation of dogs could do. In detailing the training of stutterers, I shall omit many points irrelevant to our investigation and shall do no more than outline the material, stressing those phases which should be borne most clearly in mind. First, I need to present some new psychological findings relative to the disease known as stuttering.

Some twenty or more stutterers at the Voice Clinic of the Psychopathic Hospital in Boston were subjected to a uniform set of visualization tests. Then there followed an introspection to ascertain whether there was any visual picture held in the mind previous to utterance, during utterance and after utterance. The relationship of the presence of stuttering to the presence or absence of these visualized pictures during utterance was carefully noted.

It was found that when stutterers stumble there is no visualization and that when stuttering is absent visualization is present. Upon the basis of this discovery a new method of treatment has been evolved which has been applied in the following manner:

Beginning with very simple methods of holding a visualized picture above utterance, we advance to more and more complicated processes of visualization coupled with certain exercises for concentration. I have noticed that in about two weeks these patients show what we might call a flowering out of mentality; that is, they acquire an ease of visualization which approaches almost to spontaneity, during speech. The situation is like the one we had before. A new function, or at least a more highly developed function, has been acquired which is amplified and extended in various ways so as to act as a new center of activity during the process of speech.

The result of this development of a new function is manifest. There occurs a delay in utterance and a waiting for the control of the higher center. A visual image is being built up and held during the process of utterance with the result that the image guides and controls the expression in speech. I have noticed that after the complete development of the new function there is never an absolute relapse to former conditions of spastic speech in cases which have been properly trained. We are justified, therefore, in the view that a new and permanently founded center of control has been developed. It is evidenced in new delays, new hesitations, new picture formations, new control of vocal expression and by an absence of the sudden,

low-reflex utterance that occurred before the training. I feel justified in the claim that something which we might call a new brain area has been developed, a new functional center of speech control.

Comparing this situation with that observed in the dogs subjected to training, we find the following similarities: A previously uncontrolled reflex, a previously sudden action devoid of inhibition in any form is in both cases changed by about two weeks of drill of the collaborative centers into a greatly modified reflex which really deserves to be dignified by the name "condition reflex." This change is so marked that there is pause, consideration and interpretation of the stimulus and the action which follows is of such nature as to show conclusively that it is controlled and directed by higher developed centers.

3. *Mental Growth in a Mental Defective.* I wish now to describe the case of a defective boy who has been for two years under a very intensive system of vocal drill. Omitting numerous unnecessary and irrelevant details, it will suffice to say that the boy was eleven years old, that he belonged to a special class in school and that one chief symptom of his deficiency was indistinct speech. Before the treatment of the case began the boy spoke so indistinctly that only his own family could understand him and it was frequently necessary to repeat what was said to him. He measured 4 4/5 years by the Binet scale. He spent most of his time sitting about the house and was interested in little.

A very intensive vocal drill extending over two years resulted in a marked flowering out of the boy's mentality which is indicated in the following particulars which were noted in the order in which they are stated:

Slight improvement in attention and in speed of utterance. This increased speed is not shown, however, in the framing of fresh sentences.

His teacher remarks upon his improvement in reading.

His mother notices stronger and more protracted effort in all his work.

He becomes interested in the meanings of words and wants to have pictures explained to him.

He learns a second poem in two days as well as he did his first one in three weeks.

He shows more interest in general reading.

His mother reports that he is growing more observing, takes more interest in people, asks who they are and what they are doing.

He shows an increased interest in writing and submits a poem which he has written at his sister's dictation.

He uses the octave twist spontaneously in talking.

He improves at school and in conversation with the neighbors.

Memorizing the *Psalm of Life* proves too big a task for him.

He improves in speed in recitation.

A change is seen in his facial expression. It becomes brighter, more expressive, more responsive.

He reads long words in the newspapers, draws some pictures, writes more and develops several minor activities which he had never had before coming to the clinic.

He shows marked improvement in telling stories at the table, putting them into short sentences. This had never been done before.

He makes remarks about the dress of persons he meets.

He learns the names of some of the months and wants to know more.

He plays baseball.

His eyes grow brighter and his mouth hints increased strength of character.

He has more control over the movements of his body.

Increased powers of concentration enable him to learn more rapidly.

A summary and application of these steps will follow.

4. *Data Derived from the Location of Brain Centers.* Just anterior to the Fissure of Rolando in the brain is located what is known as the great motor area. This motor area controls the motions of the leg, arm and face. The area for the leg is at the top, that for the arm is in the middle and that for the face below. Opposite the arm area and a little way out into the frontal convolution is built up the area of writing. It is the function of the area of writing to control finer motions of the hand than can be managed by the motor area below it. You recall, also, that it requires a long time to build up this writing area. It is never inherited nor is it quickly acquired. There are, then, low motor areas governing the more generalized actions and high, built-up or painfully acquired motor areas which govern the more delicate and complicated actions. This distinction holds not only for the motor side of the brain's construction but for the sensory side as well. Just behind this same Fissure of Rolando is what is known as the great sensory area, divided in a way similar to that of the motor area. Above the arm region of this area, where sensations from the arm are recorded, is built up a higher area whose function it is to interpret these sensations. This function of interpretation is known in neurology as stereognosis, and when there is an involvement in this area a pathological condition results in which the patient is unable to interpet sensations. This condition is known as astereognosis.

Let us turn now to the cortical areas related to some sense other than that of feeling. Take, for example, the sense of sight. The low sensory impressions received through the eye are reported in the area of the occipital lobe known as the cuneus. Those low eye sensations are then interpreted by an area of the brain which lies around a corner, so to speak, from

the cuneus. This function of interpreting sight impressions is called "psychic seeing." For a very simple illustration of this, take the following: I pass through the street and impressions of dark moving objects are made upon my retina and thence upon my cuneus. But I do not stop there. I interpret these impressions and sensations. I find that the dark moving objects represent people and I distinguish, among these people, between strangers and friends. That is, in neurological terms, I carry the sensation round the corner, outside the cuneus and into the area of psychic seeing.

If I were to try to picture the architecture of the brain on both its motor and its sensory side in a word, I should say: there are low sensory areas for the deposit of sensation and there are high sensory and motor areas for interpretation and guidance. The architecture of the brain is an intricate complex of forcibly evolved low-sensory areas, low motor-areas together with higher interpretative sensory areas and higher guiding motor areas.

It would be well, perhaps, at this juncture, to still clarify the points already made by referring to the pathological phases of brain anatomy and physiology. The scheme of cerebral architecture just given is confirmed by pathology. It is well known that when injuries to certain brain localities occur the functions of those localities are lost and that if degeneration results the functions never return. Suppose that a man has a hemorrhage that results from pressure over the motor area of the right side and that this extends into the inferior frontal convolutions and overlaps anteriorly, covering the back part of the central frontal convolution. This results, as you know, in a hemiplegia or one-sided paralysis of the opposite side of the body, with loss of motor speech and of the power of writing. In the parts of the brain just mentioned the cortical areas of motor speech and of writing are involved. Now when such a lesion occurs and the hemorrhage extends no further, the patient can hear what is said to him, can contemplate and think about what he hears, but he can utter nothing. In other words, his sensory speech area, which is in the middle of the first temporal convolution, receives impressions. These impressions are interpreted by the nearby areas and the interpretation is modified by certain thought processes. But when the patient tries to express himself in speech or writing his efforts are blocked. He can gesticulate and express his wishes or conclusions in this way, but as far as motor expression in words is concerned he is dead.

Suppose we locate the hemorrhage in another region, such

as that of the occipital lobe. Suppose that we have a hemorrhage just outside of the cuneus and over the corner of the occipital lobe, in the area in which, as we have noted, the function of psychic seeing is exercised. If this area of nerve cells is destroyed there results an inability to interpret eye sensations which is known as psychic blindness. The patient can see his friends but he cannot recognize them.

I have adduced data from several different fields of investigation not with the intention of communicating new or even unfamiliar facts alone but with the design of bringing together the fundamental notions which I shall have to deal with later. What conclusions are we justified in drawing from the data already considered? The conclusions most germane to our present purpose are as follows:

The experiment with the dogs shows that a superior controlling center can be developed by drill even in the lower animals to such an extent as to dominate and modify actions under certain conditions.

The effects of vocal drill upon the stutterer show that an abstract speech-controlling center may be opened up which, by long and persistent work along certain definite lines, may be largely developed. There is a curious uniformity between the cases of the dogs and the stutterer in the fact that the arrival of the two developed centers was noted in about two weeks after training began.

The growth of the mental defective through long years of drill shows that an extended series of cortical centers,—low sensory, interpretative sensory, collaborative and controlling motor—can be forced through a long series of developmental periods. Watching this case step by step, we can almost see the arrival of the different functions in succession. The picture, moreover, is interesting as a sort of epitome of normal development. In its early years the child spends most of its mental effort in sensory registration. Later there is a period of sensory interpretation. By and by collaborative processes take the lead and, with them, a marked control and guidance of expression. I do not mean to imply that there is no activity prior to the completion of this evolution, but at first there is surely some sensory registration minus its motor expression. Then the motor expression develops along with all these other periods: First, sensory registration, together with a sort of reflex motor expression that lacks interpretation and collaboration. Then follow the growth of interpretative and collaborative processes respectively until finally a complex and intricately inter-related mental mechanism is built up. All

this is to be seen in epitome in the case of the mental defect. His training acts upon his sensorium until reflex action results. Interpretation is built up and collaboration is added to it and the mental expression is dominated in turn by all the different stages of growth.

Anatomically, pathologically and experimentally located brain areas afford evidence that the whole cerebral system consists of a variety of centers, sensory and motor, with higher centers above each to interpret and control. This scheme of architecture is seen throughout the anatomy of the brain. The anatomical method of investigation locates these areas in specific parts of the brain and shows how the centers are built up near each other as well as their relationship to other centers. For example, we do not find the function of stereognosis near the cuneus or the function of motor speech in the temporal lobe. Stereognosis is located just above the arm area, where it should be. Motor speech is located just above the face area, where it should be. There is therefore a certain logical system in the location of these numerous cortical areas. And anatomy also gives us ground for assuming an inter-relation between these areas. We find that there are nerve fibres running from one convolution to the next or running from one convolution to the next but one or extending to more distant points on the same side. There are cross fibres which connect one side with the other. One author has gone so far as to say that all centers are related to all others. As we have seen, cerebral pathology provides evidence that supports this localization of functional areas and we can readily see, by the aid of pathology, how and why other areas are left free to act when the function of one area has been destroyed. Pathology also shows that even a few centers may continue to act after many are gone. The experimental method, used only upon the lower animals, offers further confirmation.

The intricacy, system and method of the brain and its functions provide one of the most beautiful examples of orderly construction to be found in all nature. Study of the brain is usually considered difficult or even uninteresting, but it ceases to be either of these when one brings to bear upon it an ability to reconstruct in the imagination its entire beautiful structure and its complicated inter-relationships. But, not allowing ourselves to be led away by the wonder of this picture, we should return to a consideration of the theoretical applications and practical results of the facts we have been considering.

1. *Theoretical Education.* These facts deserve application to several spheres of knowledge. I doubt whether educational

methods have in all cases been formulated and promulgated with a proper regard to what is known of the anatomy and developmental possibilities of the brain. Let me give one example. The Binet tests for intelligence are supposed to tell at what age a child should know certain things. In more scientific terms, Binet tests relate or compare the real age with the psychological development. These tests were based, originally, upon observations of French school children. When the system was transferred to America it was found that since American education follows somewhat different lines a modification of the French tests was necessary.

Now, if there is this difference between French and American children, there may also be a difference between every two children—a difference determined by the centers with superior interpretative and collaborative activities which have been especially or particularly developed. Therefore, I see no reason why another entirely new inter-relationship of developmental areas might not be instituted in infancy and worked up, with the result that the age type would be entirely changed. I see no reason why it should not be possible to conduct education solely along individual lines, leaving all others out. Such a process as this may account for prodigies of precocity, genius, and the like. Why, for example, can we not all have the exquisitely perfected development of the sense of hearing possessed by the blind child or the extraordinary activity of the cuneus of the deaf child? It is obvious that there are tremendous possibilities in this untrodden field and that their bearing upon education is of great importance.

2. *Type Study of Man.* Individual development along definite lines results finally in what we all agree in calling by the vague name "individuality." We hear, for example, of a "legal mind," and there might just as well be other terms such as "medical mind" or "psychological mind." There might even be a certain constant connotation behind the term "student mind." Suppose we analyze the meaning of that last term, "student mind." I choose it because it is less definite, less accepted, less formulated than the others. It may be well to narrow it a little and discuss the "Harvard type of student mind." The Harvard type of student is forced for four years along certain definite lines. They claim in Cambridge that they develop individuality. I may be allowed to criticize this view because I hold three Harvard degrees. What they actually do do is this: They force the student to listen, then they force him to write down what he hears, with little collaboration and with little effort to digest or think over

the material which passes through his ears and off the tip of his pen. At last the student is called up to another situation where the demand is made that he write the material all out again. Now, what sort of type is being developed here? A listening, slightly collaborating, writing individual. And this is the standard type of student put forth by Harvard. There are indeed many exceptions and a great deal depends upon the courses taken, but I think that in general my characterization of the typical Harvard student holds. He is a listening, slightly collaborating, writing individual.

I first became acquainted with this type of mentality while teaching neuropathology and ever since that time I have made a strenuous effort to modify the type into another and entirely different type. I thought of the matter in this way: These students take notes; they have little time to digest the subject matter; they simply write it down, and keep on writing it down for four years. Anatomically, this results in great activity of the hearing center in the temporal lobe, little collaboration in the higher centers, large development of the writing area—the listening, slightly collaborating, writing individual. It occurred to me to wonder what these students ought to be and I concluded that I should try to develop a type of student who saw, fully collaborated and talked; that is, a man who had developed his cuneus, his higher collaborative centers and his motor speech areas. The methods employed to this end need not detain us. I mention the matter only to show how the abundant data at our command may be used not only to describe or to treat the type of human beings now in the world but also to provide a basis for the evolution of better types in the future,—an educational application.

3. *Vocational Prophecies.* The data we have reviewed have an important bearing upon the choice of a vocation The different vocations demand different types of individuals and they find them only with difficulty. One cannot readily tell whether a given individual belongs to the required type or not. But if we could evolve some method of type registration which would describe the whole past mental constitution and all the inter-related activities of the present and all lines of possible future growth, we should have accomplished something of inestimable value both to the individual and to society at large. This would solve in a new way the pressing problem of the choice of vocation. But this is not the place in which to elaborate the matter.

4. *Ultimate Divisions of Consciousness.* The general prob-

lems of consciousness have, of course, been studied with great care, but certain important ones remain unsolved, unattempted. Southard has tentatively located consciousness in the post-pallium; that is, behind the Fissure of Rolando, but he makes no more minute localization of subdivisions. His statement is satisfactory as far as it goes, but on the basis of the data just reviewed we are justified in carrying the subdivision much further.

If our different sensations become conscious in different brain areas and these are widely separated and also inter-related and their inter-relations become conscious, then there is room for an elaborate division and for minute localizations of consciousness. Consciousness should be divided not only into low sensory areas, interpretative areas and collaborative areas, but into more minute subdivisions of each of these so that our ultimate divisions of consciousness would be those which correspond to all the different and separate brain localizations.

With all its ramifications and intricacies, this problem is extremely interesting and important, but we can do no more than mention it here as one deserving of more attention.

5. *Theories of Mental Measurements.* Of all the different fields into which it would be possible to carry the developmental data which have been reviewed, I have chosen only this final one for extended consideration. Even of this one I do not propose to make an exhaustive presentation but only to outline some of the theories and foundation principles that should dominate any complete discussion of the problem of adult mental measurements. I shall discuss the subject under the following three heads:

First, I shall construct a theory of cortical center relationships. Second, I shall suggest a theory of the inter-relationship of ideation components. Third, I shall present a theory of age relationships.

1. *A Theory of Center Relationships.* I have mentioned the dogs that showed development of one conditional reflex. I have mentioned the defective who built up in himself several related centers. I have mentioned other psychological developments which showed still more complex relationships between the centers developed. In all this there seems to be evidence that centers should be taken into consideration in mental measurements. Low sensory centers of perception should be considered, then the higher centers which interpret them should receive attention, then the collaborative centers

which work upon the interpreted sensations should be taken into the account. We have seen, moreover, that the motor expression of these processes is controlled by higher areas also, and these must not be omitted. Having, then, this serial view of cortical centers, we must necessarily consider all the functions of the individual mind—not only all its perceptions but all its interpretations, all its collaborative methods and all its inhibitions of output.

I do not wish to be hasty in discarding all of the many methods of mental testing now in vogue, but one can have little hesitation in saying, after careful examination of them, that they are limited, narrow and unsatisfactory. The Binet scheme, which is valuable in testing children up to the age of twelve or fifteen, is of doubtful value in the last two or three years. The Yerkes point scale which has improved the methods of testing children between the ages of twelve and fifteen is not applicable above the age of fifteen. Haines has recently presented a new system for use with the blind. Nute, of the Immigration Bureau, has another method which is adapted for use in the immigration service, and I have just heard that Haberman of New York has devised another scheme which differs from all the rest.

The problem has been attacked only recently and it is still too early to expect a perfect system. The mere fact that there are so many systems in use is a sufficient criticism upon them all. The rapidity with which new ones are devised shows that the old ones are unsatisfactory. The principal defect to be noticed in them all is that they have not taken into account all the possibilities of center growth. As systems, they have not been all-inclusive and exhaustive. Often they have fallen into the historical pitfall and have tabulated or systematized only the situation of the moment. By the historical pitfall I mean this: Hysteria was once diagnosed as a uterus running round the body; then came Babinski who said that hysteria is due to suggestion. Then came Janet, with an exclusively psychological eye, who held that hysteria is a limitation of consciousness. Now comes Freud, with a propensity for interpretation in terms of the subconscious, and he says that hysteria is an external manifestation of subconscious complexes. As another illustration, let us consider stuttering: This disease was once diagnosed as trouble with the tongue and the tongue was operated upon, a part of it being excised. Since that time the seat or location of the disease of stuttering has been pursued through both sides of the nervous system and into the brain and a new diagnosis and new form of treat-

ment has been devised for every part. Last spring it was chased into the subconscious. This summer it has been driven into the thymus gland. This fall, as the result of a long psychological investigation, it has appeared for the first time in the conscious side of the mental makeup and in association with conscious collaborative processes. About the same thing may be said of psychiatry. First came the demonological theory and then the governmental conception. Next, there was a long period in which the clinical interpretation was dominant, but now the subconscious and psychological phases of these investigations occupy us almost exclusively.

I am not certain, but I suppose that the case is much the same with philosophy and that each philosopher's system is simply the psychologizing of his own individual type of mind. This is what I mean by the "historical pitfall." All along the ages students have been interpreting and explaining one man in terms of another. There have been so-called Platonists and Aristotelians for two thousand years. Thus all thinkers have been in the pit except those who have dared to climb over the edges and to see the broad horizon with their own eyes.

All this has its application to the mental test problem of today. It is very desirable that some one should outline and master the situation as a whole and, instead of tinkering at the systems already in use, devise one which shall include the good points in earlier systems, avoid the weaknesses and supplement the deficiencies.

At present we can do no more than outline the theory which should be followed in this matter, but the theory should be one that includes in its consideration all of the brain centers. I disagree with those who would begin their tests upon children at the age of two or three. There should be a complete tabulation of all that has been deposited in the sensorium up to that age. Has the child heard exquisite music for two years? Has he been subjected to an exquisite variety of smells so as to develop the corresponding sensorial area to a high degree? Have certain attitudes of individuals towards each other in the child's environment been so obvious, so repeated and so drummed in as to determine the child's later action when he comes to act for himself? Even these few suggestions will show the inadequacy that there is in beginning mental tests by tabulating the output at the age of two or three.

The theory of centers should really enable us to find the amount of sensorial intake, its length of time and its quality. This should be determined for all sensory areas. Then I

should tabulate all the interpretative reactions upon these sensory intake areas, those that are spontaneous, those that are consciously taught and those that are forced upon the individual, whether accepted or objected to. After this, I should pass into the collaborative area and use a tabulating method to record all the processes and uses to which the intake material has been put. Finally, the motor control area should be studied in its methods of sifting, inhibiting and guiding expression.

We have been considering a theory of cortical centers and have spoken repeatedly of a relationship between cortical centers, but the exact nature of this relationship has not been discussed. It will be well to treat this matter more definitely.

2. *A Theory of Whole and Part.* I shall try to present an outline or method to be used in correlating exhaustive data tabulated from mental types. As an illustration, consider the painter who is in the act of composing a picture, in his mind. As a first step, he thinks the matter out as a whole. That is, he seeks a motive. This motive lies in a vague outline; it is the first conception, the first vague hint or intuition of the picture that is to be. His first step, then, is to select his *whole*. After this has been chosen and fixed, his mind turns naturally to the parts of his picture, mass, color, form, background, and in a more or less tentative way he selects certain details that may be included. In simple terms, this may be said to be his consideration of the *parts*. Next he thinks out the *relation of these parts to the whole*. He tries to make each of them serve and support the whole in some way. Finally he turns to what is perhaps the most difficult phase of his work. He begins to consider just how the parts *should be related one to another*. Thus we have a consideration of the whole, of the parts, of the relation of the parts to the whole and of the relation of the parts to one another as four pretty distinct processes which the mind of the artist must pass through, consciously or unconsciously, in order to complete his picture.

This may serve as a guide in our study of the theory of centers. We should begin by considering the individual or the type as a whole; then we should tabulate the parts of this type or individual as parts of the whole. Next we should tabulate the relationships of these parts to the whole and finally we should consider the relationships of the parts to one another. It is clear, at least, that a methodical procedure such as this must be far better than no method whatever.

3. *A Theory of Age Domination.* It is well known that mental measurements bear a definite relation to age periods. Viewing life as a whole, we are reminded of Shakespeare's seven divisions, but when we view it from the plane of the history of philosophy, the history of education, the history of practical business life, we are warranted in making certain deductions that do not harmonize with the division made in *As You Like It.*

The life of a normal human being who reaches old age is divided into four overlapping but distinct periods. Each of these periods is dominated by a different attitude towards the world and towards himself.

The first period lasts until puberty. It is dominated, as I see it, by sensorial registration. That is, registration of sensations upon the cortical areas is the dominant mental activity. Other mental activities are either undeveloped or are dominated and overshadowed by this one. There is little besides registration. This may be called, very vaguely, the "sense-period."

The second period begins at puberty and lasts for several years. It is marked by a profound mental disturbance as well as by many well-known physical changes. In this period a new center comes into activity which takes precedence over all others and guides and transforms the whole nature. This period may be described as affective, interpretative and it may be called the "period of affection."

In the third period another form of interpretation dominates. The affairs of life are taken up in relation to a developed personal self and they are decided upon, rejected or accepted in relation to that self's aims, hopes and ideals. In this period there is, of course, an element of each of the earlier stages, but these have lost their dominant and directing power. This may be called the "period of will."

The fourth period is that in which the collaborative processes of the individual finally become dominant. He is now, chiefly, a thinking being. All the other spheres or phases of his activity are taken up into this last one, but he regards them as mere avenues to this final goal or station of thought. He lives in those old shells of sensory registration, affection and will, to be sure, but he is no longer dominated by them. He is not led hither and thither by their overpowering influence. He is now led only by the workings of his developed collaborative processes. This period may be said to begin at the age of forty and to last perhaps to death. The period

might be called collaborative, but we may dominate it more simply, the "period of intellect." Now let's put this all together.

I have tried to show that all these related theories serve in the formulation of exhaustive tabulations of mental tests which should cover the *entire life* with all of its variations. Mental tests should relate all sensorial content, all interpretative reaction, all forms of collaboration, all controlled methods of expressive output according to the correlations laid down in the theory of the whole and the parts. It should be kept in mind that these are dominated in the different life periods by sense, affection, will and intellect respectively, each of which is relegated in succession to its subordinate place. These should be related in such a way as to picture the past, present and future of all possible mental types in their perfected development and the percentage relationship should be shown between the present individual and his final, ultimate, developmental perfection. Thus I would summarize my paper.

So long as we confine our discussion to matters of theory we may picture to ourselves an ideal which is realizable, if at all, only in the dim future. This is what I have done. I grant that an exhaustive tabulation of really exhaustive mental tests is, according to our present knowledge at least, unthinkable. But theory works in the ideal. Practice, when we come to it, may lead into new scientific relationships.

FACTORS WHICH INFLUENCE THE AROUSAL OF THE PRIMARY VISUAL MEMORY IMAGE

By HAROLD E. BURTT, Harvard University

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I. INTRODUCTION

The development of the problem of individual differences in imagery subsequent to the time of Galton has led away from the original simple solution to an increasing realization of the complexity of the whole matter. We note the failure of investigators to find simple types and the disputes as to the actual criteria of type. Fernald has recently stated that "individual differences in imagery are too complex to be stated in terms of differences in type unless this type is carefully explained in the individual case,"[1] and suggests that perhaps "individual differences may be more profitably stated without the incubus of types,"[2] while Lipmann[3] thinks that a further differentiation is necessary within the visual according as individuals best apprehend (auffassen) hue, saturation, brightness, size, or position.

In view of the present rather unsatisfactory status of the traditional problem of types, and of the nevertheless patent fact that individuals differ markedly in their mental imagery, the present investigation proposes to approach a limited aspect of the question within the field of visual imagery. The effect of certain fairly controllable factors connected with a visual

[1] M. R. Fernald, The Diagnosis of Mental Imagery, *Psychological Monographs*, XIV., 1912 (No. 58), 130.
[2] *Ibid.*, 21. [3] O. Lipmann, Visuelle Auffassungstypen, *Bericht IV Kongres für experimentelle Psychologie*, 1911, 198.

stimulus upon the immediate arousal of visual imagery of that stimulus was studied. Complexity of contour, size, length of exposure of an object, interest aroused in an object, motor reinforcement by tracing, motor distraction and mental distraction during fixation were selected for investigation and their effect upon imagery of the object was determined. These are only a few of the many variables that might be made the subject of profitable study.

The determination of imaginal types in the present case is wholly incidental. The interest of the experiment is four-fold:

1. How far do the above factors, operative during a period of visual stimulation, influence, in general, the arousal of imagery of the stimulus?

2. How far do individuals differ quantitatively in their susceptibility to these various factors?

3. How far do individuals differ qualitatively in the means by which these factors operate in influencing the arousal of visual imagery?

4. How far, if at all, are these factors interrelated?

Two previous experiments have dealt specifically with a few of the above factors. Meakin,[4] working with pairs of plane figures and noting the subsequent rivalry in imagery, finds that the larger or longer-exposed object or that with a notched contour persists in consciousness during a greater part of a given interval than does a simple object. Murray,[5] working with single exposures of simple figures, finds no correlation of duration or excellence of reproduction in imagery with complexity and size.

The other factors involved in the present investigation have been brought out only incidentally in previous experimental studies. Meakin[4] mentions interest as a cause for the more frequent occurrence of images of certain figures. Kuhlmann[6] using pictures of familiar objects as stimuli for imagery, concludes that the tendency for the image of a picture to become that of a real object is due to the fact that there is "more interest and emotional coloring to objects than to pictures." Martin[7] notes that, according to the introspection, the duration of imagery frequently depends on interest.

[4] F. Meakin, Mutual Inhibition of Memory Images, *Harvard Psychological Studies*, I., 1903, 235-275.

[5] E. Murray, Peripheral and Central Factors in Memory Images of Visual Form and Color, *American Jour. of Psychol.*, XVII, 1906, 227.

[6] F. Kuhlmann, Memory Consciousness for Pictures of Familiar Objects, *American Journal of Psychology*, XVIII, 1907, 420.

[7] L. J. Martin, Die Projektionsmethode und die Lokalisation Visueller und anderer Vorstellungsbilder, *Zeits. für Psychologie*, LXI, 1912.

The motor element in visual imagery is repeatedly emphasized by Meakin and he concludes that the factors which he studied (such as size, complexity, broken lines, etc.) are the "conditions which determine the energy diversity, complexity and definiteness of the active process involved in the bestowal of attention upon its object; and . . . such active processes are as essential in ideation as in perception."[8] Kuhlmann, using meaningless forms which are memorized and recalled after an interval, finds motor tendencies in the imagery and these are in some cases "real aids to recall."[9]

Meakin mentions attention in the above quotation. Slaughter[10] notes that the distribution of attention in imagery and stimulus are similar. If a row of dots is followed across with the eyes, the dots can be brought out successively in imagery. Martin[7] states that, according to the introspection of the subjects, the duration of imagery often depends upon attention. Distraction has sometimes been employed in tests of imaginal type. The mode of distraction (visual, auditory, verbal) which produces the greatest effect upon the objective results of a learning "Aufgabe" is supposed to indicate that the subject belongs to the corresponding type. The method has been used with considerable success by some investigators, but it is sometimes found that the distraction has no effect upon the imagery.[11] In the present experiment, however, the method is somewhat different,—the distraction being employed during the stimulus period and the effect upon *subsequent* imagery noted.

II. Apparatus and Method

Each of the seven variables above mentioned was studied, in the present investigation, from three standpoints.

1. *Single* exposures were made of simple geometrical figures, some trials involving and others not involving the given variable. The time necessary for arousal and the time of involuntary holding of subsequent imagery under the former condition was compared with that under the latter.

2. *Simultaneous* exposures were given of two figures, one of which involved the variable under consideration. The rela-

[8] F. Meakin, Mutual Inhibition of Memory Images, *Harvard Psychological Studies*, I, 275.

[9] F. Kuhlmann, Mental Imagery and Memory of Meaningless Forms, *Psychological Review*, XIII, 1906, 344.

[10] J. W. Slaughter, A Preliminary Study of the Behavior of Mental Images, *American Journal of Psychology*, XIII, 1902, 535.

[11] *Cf.* J. E. Downey, Central Processes in Modified Handwriting, *Psychological Monographs*, IX, 1908 (No. 37), 99.

tive predominance of the two in imagery was noted, and compared with the results of the check series in which neither figure involved the variable. The times of arousal and holding of the imagery under the two conditions were compared.

3. The *successive* exposure of two simple figures in check series usually yielded a marked predominance of the second in subsequent imagery. By introducing a hypothetically reinforcing variable on the first object or a distracting one on the second, the effect in reducing the predominance of the second could be noted. The times of arousal and holding of the image in the crucial and check series were compared.

The variables were controlled by the nature of the stimulus object or by the "Aufgabe" during the stimulus period. Figures with notched edges, with twice the usual area, with longer exposure, or figures representing in outline certain meaningful objects, were used to control complexity, size, exposure length and interest respectively. Motor reinforcement consisted in the subject's tracing a figure on the table while fixating it. Motor distraction was produced by writing extraneous words during fixation. Mental distraction consisted in performing mental addition while observing the figure.

An experiment of this sort necessitated an exposure apparatus that would provide a means of eliminating sensory after-images by a flash of light prior to the mid-period, and that would accurately control the time relations of the stimuli.

A few of the earlier series were performed with a relatively crude apparatus, Hering's *Nuancierungsapparat* adapted for the purpose. This consisted of a box 94 x 30 x 20 cm. with one of the broader sides open, and mounted vertically with the open side facing a north window. The subject sitting on a high stool with his forehead on a rest, could see, through a small aperture in the top of the box and through a diagonal piece of glass, the black rectangular field at the bottom. When the experimenter pulled a string, a black cover fell across this field and automatically opened a door on the side of the box which admitted light reflected from a piece of milk glass outside. This light was reflected upward from the diagonal piece of glass in the box to the eye. The stimulus object of black cardboard was placed on the field and at the signal "ready-open," the subject opened his eyes and fixated the object for 5 seconds until the experimenter, noting a stop-watch, pulled the string. As soon as the flash appeared the subject closed his eyes and observed the imagery that arose, signalling its appearance and disappearance by raising

and lowering the finger. The experimenter took the time with a stop-watch.

The majority of the work, however, was performed with an enlarged and somewhat modified Dodge tachistoscope.[12] This consists in principle of a box with black interior with two exposure fields at opposite corners visible through an opening at the third corner,—one field, when illuminated, seen directly through a diagonal piece of smoked glass and the other, when illuminated, seen reflected from the glass which with dark background acts as a mirror. The present apparatus was 25 cm. deep with the 25 x 25 cm. fields 96 cm. from the rectangular opening hooded for the eyes of the subject. The fields were illuminated by light from two 25 watt tungsten lamps reflected by mirrors outside the range of vision. A third lamp was placed inside the apparatus just to the right of the smoked glass in such a position that its filaments were thrown out of focus on the eye by a 10 cm. condensing lens. A slit 70 x 8 mm. in a cardboard screen admitted a small portion of the light from the filaments. This was sufficiently strong to destroy the after-image, but not sufficiently so to cause discomfort. The lamps were on separate circuits and by proper control the stimulus objects appeared successively in the same apparent position followed by the flash of light. The apparatus rested on legs on a table with the hood on the level with the eyes of the subject sitting on an adjustable chair. The experimenter sat at one side of the apparatus at a table containing the switch-board, stop-watches and material for stimuli.

A slit was cut in the cover of the apparatus above each of the exposure fields to admit the insertion of pieces of 25 x 25 cm. cardboard with the stimulus objects pasted or drawn upon them. One field could be reached from the experimenter's seat, but the other could not without standing up and reaching across the apparatus. At this latter were installed four traveling frames of light brass suitable for holding stimulus cards. Their contiguous surfaces were perfectly smooth and they were operated from the experimenter's seat by strings and pulleys so arranged that any frame could be pulled into position and the others drawn to one side. The field was masked so that no brass was visible. The frames were loaded at the beginning of the hour's work and it was thus possible to avoid much confusion and save considerable time during the series.

[12] *Cf.* R. Dodge, An Improved Exposure Apparatus, *Psychological Bulletin*, IV, 1907, 10-13.

The length of exposure of the stimuli was controlled by means of the circuits through the lamps. A wooden disc 22 cm. in diameter, mounted on an axis, was driven at the rate of 3 revolutions per minute by an alternating current motor reduced by belt gear. On this disc were mounted three brass contacts in the form of arcs of circles of different radii having the axle as the common center. The radius drawn to the end of one arc marked the beginning of the next, so that, as the disc revolved, they would in succession pass a given radius. Three contacts of spring brass, with their free ends in the same line were adjusted to press in succession upon the contacts on the disc. Thus during a part of the revolution the first spring contact was on the first contact on the disc; just as it reached the end of the arc and pressed against the wood, the second spring contact pressed on the second contact on the disc, etc. The contacts on the disc were connected with the axle and mounting and thus to one pole of the lamp circuit. The three spring contacts led through the three lamps respectively and joined at the other pole of the main line. Thus the three lamps were lighted in succession, one disappearing just as the next appeared. The first arc on the disc was stationary and of the proper length to give a 6 second exposure. The second was pivoted at the end nearest the first and held in position by friction in a narrow slit sawed in the wood along the arc. The length of the contact could be shortened by pushing the free end farther through the disc so that the spring that rested on it would touch merely the wood. The third arc was of the proper length to give a one-second exposure and was soldered to a strip of brass passing under a screw clamp at the axle so that it could be moved along in a shallow groove to a position immediately following the end of the second contact. Thus the two objects in the tachistoscope could be shown successively for various lengths of time followed by the flash of one second. When it was desired to use single exposures a switch in the circuit of the first lamp was opened. Other switches made it possible to reverse the order in which the first two lamps were lighted or to have one lamp lighted by both of the first two contacts. In part of the work, the motor and lamp-controlling mechanism set on a table with the tachistoscope, but later they were moved to an adjoining room and the wires led through the wall. The sound of the motor was never noted as a distraction by the subjects and furthermore it was a constant factor.

To record the time of arousal and holding of imagery two stop-watches were used. One was of the football type, started

and stopped by plungers at the side. It was mounted with two short strips of brass, each pivoted at one end resting on the respective plungers. The free ends were connected by light steel wires through screw eyes to the armatures of two telegraph sounders. These latter was actuated by a make-and-break key operated by the subject. With the key in its normal position the sounder which pulled the lever against the "stop" plunger was in operation. When the subject pressed his key it broke that circuit and closed one through the other sounder which actuated the "start" plunger. When the key was released the original circuit was again closed. This watch was used to record the time of holding of the image. The other watch was of the ordinary stem starting type and was mounted horizontally with a strip of band iron pivoted a short distance to one side of the stem. Opposite the end of this was a horseshoe electromagnet which could be operated by two parallel circuits. The first of these was closed by a contact at the proper point on the rotating disc which controlled the exposures in the tachistoscope,—a piece of brass on the disc brushing across two poles 2 mm. apart. The second circuit was closed by a relay in connection with the sounder which started the first watch. Thus the watch started automatically just as the second object disappeared in the tachistoscope, and stopped when the subject signalled the presence of the image by pressing the key.

The materials for the experiment consisted, except in the series on interest, of simple geometrical or meaningless figures. None of the polygons had more than six sides and the curved figures were comparatively simple. The figures were uniformly of 36 sq. cm. area with the exception of some of twice that area used in the study of the effect of size. Those used in the "*Nuancierungsapparat*" were cut from black cardboard and were exposed upon a field of the same material. Those employed in the Dodge tachistoscope were of white paper pasted on black cardboard, or were drawn in outline wth ink on light grey cardboard. Those used in single and successive exposures were centered on the card. Those used in simultaneous exposures were side by side with a space of 2 cm. between their nearest points. In the latter case the space error was always obviated by presenting the two figures in both space orders in different trials. Similarly the time error on successive exposures was controlled,—the same figure occurring first in half of the trials in which it appeared, and occurring second in the other half.

The instructions given to the subjects in previous experi-

ments involving a definite visual Aufgabe have varied considerably. Meakin[13] and Murray[14] instructed their subjects to await passively the entrance of the image into consciousness. Martin[15] and Ogden[16] told theirs to "get an image." Perky's instructions[17] were to be on the lookout for images. In the present experiment the subjects were given two hours of preliminary training in which they were instructed to "call up a visual image of the object just seen, observing it as passively as possible and signalling its presence by pressing the telegraph key and its disappearance by releasing the key." These instructions rapidly passed into a determining set and in all subsequent work, after being told to fixate the figures that appeared or to fixate between them (on simultaneous exposures) or to perform the required operation during fixation, the subject was merely instructed to "close the eyes after the flash and observe whatever imagery arises, pressing the key when the image appears and releasing it when the image disappears." These instructions were given at the outset of the hour's work and not repeated during the series. After each trial the subject described the image and the introspection was recorded verbatim.

Visual stimuli seemed more suitable for an experiment of this sort than word stimuli, for they afford a better objective control of the variables under investigation. Word stimuli would in the present case be more liable to introduce extraneous factors such as suggestion. Moreover the visual stimulus affords a better control of the subject's state during the foreperiod, for he is always observing a figure for 5 or 6 seconds prior to the mid-period in which the image appears.

That after-images did not play a part in the experiment seems evident from the intensity of the flash that followed the exposures. The subjects frequently noted a momentary after-image which was "wiped out" by the flash. Furthermore the qualitative aspect and the temporal course of the images for a given subject were fairly similar whether the

[13] F. Meakin, Mutual Inhibition of Memory Images, *Harvard Psychological Studies*, I, 1903, 237. [14] E. Murray, Peripheral and Central Factors in Memory Images of Visual Form and Color, *American Journal of Psychology*, XVII, 1906, 229.

[15] L. J. Martin, Die Projektionsmethods und die Lokalisation Visueller und anderer Vorstellungsbilder, *Zeitschrift für Psychologie*, LXI, 1912, 329. [16] R. M. Ogden, Experimental Criteria for Differentiating Memory and Imagination in Projected Images, *Psychological Review*, XX, 1913, 379.

[17] C. W. Perky, Experimental Study of Imagination, *American Journal of Psychology*, XXI, 1910, 428.

stimulus was a white figure on a black field, a black cardboard figure on a black ground or a figure drawn in outline with ink on a grey card.

In some of the previous work of other experimenters the imagery has been observed during a definite interval,—frequently a minute,—the successive appearances of the image being recorded. The present work dealt only with the primary visual memory image. Subsequent recurrences after the first disappearance of the image were not taken into consideration. In one series the times for the primary and for the recurring image (i. e. the total time the image was present during a minute) were recorded for four subjects,—about 60 trials each. The coefficients of correlation between the two times by the Pearson product-moments formula were:

.6056+.063
.4710+.089
.4298+.089
.4004+.075

If as satisfactory results can be obtained by using the primary image which lasts from 1 to 20 seconds as by using the recurring images for a minute, the great saving of time is evident.

The experiments were performed in the Harvard Psychological Laboratory during the academic years 1913-14 and 1914-15. Fourteen subjects participated at various times in the work. Of these one was an instructor in the department, nine were graduate students (two of them women) and three were undergraduates of considerable psychological experience. The entire experiment comprises reports on approximately 5500 images.

The writer expresses his sincere obligations to Professor Herbert S. Langfeld and Professor Hugo Münsterberg.

III. Experimental Results

A. *Complexity of Contour*

The results of the experiments on complexity of contour are summarized in Table I. The first column gives the subject. The next two give the results for single exposures,—the % superiority[18] of the notched series to the simple, i. e., the % by which the average time of holding is greater, and the difference between the two averages divided by the probable error of difference. The next six give the results for simultaneous exposures. The introspective accounts fall readily into trials in which the notched or simple figure predomi-

[18] Percents reckoned in terms of the smaller figure throughout the work.

nates in imagery (i. e., is clearer or more persistent) or in which the two figures are equal. The table gives the % of the trials in which the notched predominates and in which the simple does so. Then follow the % superiority of the notched series to the check series (with both figures simple) in times of arousal and holding, i. e., the % by which the average time of arousal is less and the average time of holding greater, with the respective differences divided by the probable error of difference. The remaining columns give the results for successive exposures. The % of trials in which, according to the introspection, the figure exposed second predominates or appears alone in imagery in the series with the notched object shown first, is divided by the corresponding % for the normal series with both objects simple. A smaller ratio in the table indicates a greater effect of the complex first figure in reducing the natural predominance of the second figure. Then follow the % superiority of the series with the first figure notched to that with both figures simple in times of arousal and holding of imagery, with the corresponding differences divided by the probable error of difference. The temporal aspect of the image in the simultaneous and successive methods is not as important as the qualitative. It merely indicates whether the images rise more quickly and hold longer when one of the objects shown involves the given variable than when both are simple,—a factor measured more directly in single exposures.

The table shows that with 6 of the 7 subjects who participated on single exposures, the notched image holds longer on the average, than the simple, with an average superiority, including the negative case, of 11%. On simultaneous exposures the notched figure predominates in imagery in 69% of the trials as compared with 9% for the simple figure, while in the check series (not given in the table) the majority of the trials yield images that are equal. The images rise more slowly and hold longer on the notched series than on the check series.[19] In successive exposures the second figure predomi-

[19] It may be noted in passing that the whole series of experiments on imagery indicates that the time of holding is a much better criterion by which to judge the influence of various factors upon imagery, than is the time of arousal. The two times were correlated for 10 subjects on about 140 trials each by the Pearson produce-moments formula. There were three appreciable negative coefficients (.23, .30 and .34) and one positive (.29) while the others were small. In many cases the subjects get into a certain rhythm of arousal which is little influenced by the character of the stimuli. The time of holding correlates more often with the introspection.

TABLE I

TABLE I
COMPLEXITY OF CONTOUR

Subject	SINGLE EXPOSURE		SIMULTANEOUS EXPOSURE						SUCCESSIVE EXPOSURE				
	TIME		REPORT		TIME				REPORT	TIME			
	HOLDING				AROUSAL		HOLDING			AROUSAL		HOLDING	
	Percentage of superiority notched	Difference / P. E.	Notched predominate	Simple predominate	Percentage of superiority notched	Difference / P. E.	Percentage of superiority notched	Difference / P. E.	Notched / normal	Percentage of superiority notched	Difference / P. E.	Percentage of superiority notched	Difference / P. E.
Br	—3.0	1.6											
Bz			75%	17%	—27.2	3.8	18.9	4.6	.40	16.2	2.7	0	0
C	14.2	1.5											
D			96%	4%	17.4	1.6	64.4	7.9	.12	—8.1	.8	14.1	3.1
F	6.3	.9											
H	15.8	1.1											
L	28.8	1.5	25%	12%	—70.8	14.7	21.0	4.7	.43	—7.1	1.7	64.1	9.8
Ms	2.7	1.0											
Mt	10.0	.8											
R			80%	5%	—290.0	12.8	40.4	7.0	.43	22.7	1.7	4.5	.6
Average.....	10.7	1.2	69%	9%	—92.6	8.2	36.2	6.1	.35	5.9	1.7	20.6	3.3

nates in imagery about 35 as frequently when the first figure is notched as when both are simple, and the images in the former case rise somewhat more quickly and hold considerably longer than in the latter.

As a further light on the single exposure method a series was performed in which the visual stimuli were not presented. The subject sat in the same position as in the previous series with closed eyes and after the signal "ready" the experimenter named the object,—"notched square," "simple square," etc. The subject was to call up a memory image of the object as he had seen it a week before and signal its presence in the usual manner. The results tend in the same direction as the above,—the complex images holding longer for 5 of the 7 subjects with an average superiority of 8.5%.

The qualitative aspect of the results in some cases throws light upon the quantitative. There are, of course, individual differences in the color, clearness, position, etc., of the image and in its mode of appearance and disappearance. Such facts, although of general interest, do not concern the present problem. Mention will be made of only those points of introspection which indicate the effect of the variable under investigation.

On single exposures with *Br* kinaesthetic and affective factors seem prominent. The notched figures are frequently reported as "clear and pleasant." The notched circle, however, is inferior in time of holding to the simple and is described as "vague kinaesthesis going around; not as pleasant as the plain circle; little jar as if rolling along and the rolling jerky; sort of kinaesthetic jar." There is also a "tendency to look around it; less of this in the image." *F* occasionally reports associations in connection with a figure that holds rather long in imagery. *H* notes that it is "easier to attend to the notched figure, for there is more complexity." *L* is very kinaesthetic and often thinks of going around the figure or notes a "kinaesthetic image on a visual background" or a figure "filled in with kinaesthesis," or "intimation of teeth on top and kinaesthesis below." This kinaesthetic aspect seems to correlate with the longer holding of the notched image. However in the check series with word stimuli, he experiences great difficulty in getting an image at all of the notched figures. *Ms* notes on the notched circle, "Revolved; associated with pinwheel" or "Associated with circular saw; teeth slanted." This associative factor tends to lengthen the time of the image. In the check series with word stimuli

the reports are somewhat similar to the preceding. *C* and *F* note movement of the eyes about the image of the notched figure. *L*, as just mentioned, has difficulty in calling up images of the notched figures and such images are less clear, slower of arousal and less persistent.

In simultaneous exposures *Bz* sometimes reports only the middle part of the two objects. This would seem to follow with the fact that the subject fixates between the two figures and the inner parts are consequently more in the focus of attention. *D* notes, "I try to divide the attention but I think the ragged one attracts me and the other fades first." *L* also shows a tendency for the portion nearest the point of fixation to be most marked in imagery. *R* states that the "notched ones were interesting."

On successive exposures *Bz* states that the notched ones are more interesting. With *L*, when the first object appears in imagery (as it does only in the notched series), it is frequently in kinaesthetic terms. In a number of trials the second takes on the notched attribute of the first. For example, "second with wavy lines;" "First, then second inside it crumply."

B. *Size*

The results of the experiments upon the influence of size are summarized in Table II which is identical in form with Table I except for the substitution of "large" for "notched" and "small" for "simple." The table shows that in single exposures the images of the larger figures hold 11% longer on the average than those of the small. On simultaneous exposures the large figure predominates in imagery in 32% of the trials as against 22% for the small figure, while the check series (not given) usually yields both images equal, and the images rise more slowly and hold longer on the series involving large objects than on the check series. On successive exposures the second figure predominates in imagery .76 as frequently when the first figure is larger as when both are of equal size and the images in the former case rise, in general, more quickly and hold longer.

As a further check on the single exposure method a series was performed in which the visual stimuli were not presented. The subject sat in the same position as in the previous series with closed eyes, and after the signal "ready" the experimenter named the object,—"large square," "small square," etc. The subject was to call up a memory image of the object as he had seen it a week before and signal its presence in the usual manner. The results tend to substantiate the above,

TABLE II

SIZE

Subject	SINGLE EXPOSURE		SIMULTANEOUS EXPOSURE						SUCCESSIVE EXPOSURE				
	TIME		REPORT		TIME				REPORT	TIME			
	HOLDING				AROUSAL		HOLDING			AROUSAL		HOLDING	
	Percentage of superiority large	Difference / P. E.	Large predominate	Small predominate	Percentage of superiority large	Difference / P. E.	Percentage of superiority large	Difference / P. E.	Large / normal	Percentage of superiority large	Difference / P. E.	Percentage of superiority large	Difference / P. E.
Br	8.0	1.3											
Bz			42%	42%	—15.3	3.3	24.4	12.2	.90	29.8	5.7	24.6	6.9
C	10.4	1.2											
D			4%	4%	1.5	.2	52.0	8.0	.91	19.4	2.2	—20.0	3.4
F	1.3	1.6											
H	44.3	1.0											
L	9.2	2.4	31%	19%	—84.0	16.4	15.7	4.4	.58	—14.0	2.7	57.2	7.1
Ms	10.4	.9											
Mt	—6.5	.6											
R			50%	25%	-178.0	11.5	25.0	5.0	.63	72.2	3.9	—5.3	.8
Average.....	11.0	1.3	32%	22%	—68.9	7.8	29.2	7.4	.76	26.8	3.6	14.1	4.5

the image of the larger object holding 10% longer on the average.

A few points from the introspection may be noted. On single exposures with *Br* there is a possible correlation of time of holding with affective tone, the large figures being frequently reported as more pleasant. *C* notes that the large image sometimes "swells up" or "spreads out" at the end. *H* is "conscious of the effort to see the whole image; the eyes seem focussing one part and then another." *L* notes occasional kinaesthesis with the large figures. *Mt* states, "In looking at the object I tend to draw the part that interests me and the image has the heavy black line I have drawn." In the series with word stimuli *C* reports the large images much larger than the original. *F* notes the images as tending to build up. *L* finds the large images more difficult of arousal, e. g., "Mostly kinaesthetic; felt self pushing it out; tendency to make it small first; the pushing seems to be in the eye muscles; larger it is the longer it takes to get it." For *Ms* the large images are much larger than the original, often starting large and growing smaller.[20]

In the simultaneous series *Bz* gets "the smaller figure as a whole, while with the larger it is a process of building up."

On successive exposures *L* notes occasionally the image of the second figure larger than the original. This is doubtless due to the influence of the first figure. He speaks of carrying in mind the difference in size.

C. *Length of Exposure*

The results of the experiments on length of exposure are summarized in Table III. Its form is like that of the preceding tables. The exposures were 5 and 10 seconds for the single exposure method. For the simultaneous, the apparatus was arranged so that one figure appeared alone and then the other beside it. A piece of 6 mm. board 25 x 10 cm. and painted black, was hinged to the edge of the tachistoscope with spring hinges in such a way that when a black thread was held taut one stimulus figure was obscured and when the thread was released the shutter flew back against the wall. The electrical connections were changed so that both contacts on the disc governing the exposures lighted the same lamp of the tachistoscope. The experimenter held the thread taut during the 6 seconds on the first contact and released

[20] It may be noted, as of methodological interest, that word stimuli have a greater effect in emphasizing an attribute of a figure than do the visual stimuli.

it at the slight flicker when the contacts changed. Thus the left stimulus appeared for 6 seconds and then both for 6 seconds. The subject fixated the first object and when both appeared fixated between them.[21] In the table are given the per cent of trials in which the longer exposed of the two predominates and in which the shorter does so, with the per cent superiority in times of arousal and holding of the present series to the check series with the objects shown together an equal length of time. On successive exposures the variable was introduced by showing the second figure for one second and comparing such trials with the normal suecessive exposures of six seconds each.

The table shows that for single exposures the longer exposed object holds some 10% longer in imagery on the average, although 3 of the 7 subjects show slight negative tendencies. The average results on the simultaneous method are identical for the long and short series. This is due to two subjects, *D* and *L*, whose introspection (infra) indicates the entrance of another factor. The average difference in the temporal aspect of the image under these conditions is slight. On successive exposures the second figure predominates about .81 as frequently when its exposure is shortened to one second as when both are shown for 6 seconds. The times are not given in the table as they show only slight differences in both directions. If, however, the holding time on the 6 and 1 second series is evaluated for the trials in which the first object predominates compared with those in which the second does so, the average of the former is 18% superior to the latter with the differences 2.4 the probable error on the average. In other words the imagery does not hold as long when the object exposed for 1 second predominates as when that exposed for 6 seconds predominates,—a result similar to that found with single exposures.

A few points from the introspection may be noted. On simultaneous exposures *A* frequently gets an "exact reproduction of the original; first one and then both." Evidently the distribution of attention in the image follows that in the stimulus. *Bz* says, "I take in the first one more quickly than the one beside something already in attention; feels as if the

[21] No other method of studying this factor from the simultaneous standpoint seems available. Showing one object alone in the center of the field followed by the same object with another beside it has merely the effect of successive exposures, and the first, when it does appear in imagery, is in the center like the original stimulus. Showing both objects and then cutting out one would leave the effect of recency which is pronounced on all the work on successive exposures.

TABLE III
LENGTH OF EXPOSURE

TABLE III
LENGTH OF EXPOSURE

Subject	SINGLE EXPOSURE		SIMULTANEOUS EXPOSURE						SUCCESSIVE EXPOSURE
	TIME		REPORT		TIME				REPORT
	HOLDING				AROUSAL		HOLDING		
	Percentage of superiority long exp.	Difference P. E.	Long exp. predominate	Short exp. predominate	Percentage of superiority long exp.	Difference P. E.	Percentage of superiority long exp.	Difference P. E.	Short / normal
A			45%	10%	—29.0	.9	—15.7	1.4	
Br	11.2	2.2							
Bz			100%	0%	.4	.1	—22.5	7.1	.86
C	17.0	1.6							
D			0%	100%	7.8	1.3	21.1	3.7	1.00
F	—5.5	.5							
G									.26
H	36.5	1.1							1.00
K									.46
L	—2.8	.2	15%	77%	—2.6	.5	21.0	2.2	1.03
Ms	17.2	1.6							
Mi	—4.4	.7							
R			49%	22%	6.1	.7	—2.1	.4	1.12
T									.69
Average....	9.9	1.1	42%	42%	—3.5	.7	—.4	3.0	.81

attention swung back to it after closing the eyes; fact it has been there longer turns the attention to it." *D* always gets the shorter exposed figure clearer in imagery. In the early trials it is covered with a "veil," but the image of that one is nevertheless clearer. Toward the end the veil is "not present so much as its effect in making the image blacker and attracting attention to it." Probably the stimulus to attention of the screened objects accounts for the results. "Knowing it is screened arouses curiosity and interest in it when it comes; there is a tendency to go to the veiled object when it appears, although I try to fixate between them." *L* reports a "decided feeling of something coming in; I fixate the first and when I move to the middle it throws the attention to the other side; I feel the attention go." The results of *D* and *L* thus cannot be considered as evidence against the positive effect of exposure length, for owing to the technique of the experiment other variables entered with them,—in the case of *D* the factor of interest in the concealed object which is to appear, and with *L* the overshooting of the motor impulse or attention in turning from one figure to the mid-point between the two.

On successive exposures with *Bz* the effect of shortened exposure is more marked than the table indicates. In the trials where the second figure predominates he states that "it is not as dominant on the shortened exposure; in the normal, the first object appears in imagery only at the end, whereas with the shortened exposure it appears relatively earlier." With *D* the second object is relatively clearer in imagery in the series with shortened exposure,—a result the opposite of the general tendency. The following introspection explains the fact: "During the second exposure I recall the first by kinaesthesis; on the short exposure the first does not have time to come into relation with the second; the kinaesthesis of the first cannot arise during the second as it usually does." *L* reports that with the short exposure the images "come immediately and are more involuntary than with the longer exposure." *K* shows a similar tendency. With *Ms* and *T* one figure carries associations and tends to predominate whether shown first or second.

D. *Interest*

The results of the experiments upon the rôle of interest are summarized in Table IV. Its form is identical with that of Table I with the interesting figure substituted for the complex. The table shows that on single exposures the images

TABLE IV
INTEREST

Subject	SINGLE EXPOSURE		SIMULTANEOUS EXPOSURE				SUCCESSIVE EXPOSURE				
	TIME		REPORT		TIME		REPORT	TIME			
	HOLDING				HOLDING			AROUSAL		HOLDING	
	Percentage of superiority interesting	Difference P. E.	Interesting predominate	Other predominate	Percentage of superiority interesting	Difference P. E.	Interesting normal	Percentage of superiority interesting	Difference P. E.	Percentage of superiority interesting	Difference P. E.
Br	—15.0	3.4									
Bz			75%	5%	12.2	4.7	.25	—7.5	1.3	3.4	.8
C	.5	.1	45%	28%	—14.8	4.4					
D							.58	—.5	.7	14.6	2.9
F	13.0	1.9	55%	7%	—46.3	11.4					
H	—3.9	.4	10%	2%	20.3	.5					
L	—1.0	.2	68%	16%	9.7	2.6	.21	—6.7	.4	8.1	.4
Ms	40.0	7.9	33%	13%	88.2	13.1					
Mt	—11.8	1.5	42%	12%	—41.0	10.6					
R							.30	56.0	4.8	15.5	4.6
Average..	3.1	2.2	47%	10%	4.2	6.6	.33	10.3	1.8	10.4	2.3

hold somewhat longer for the meaningful figures. Some of these figures, however, were much more interesting than the others. If the results for the three most interesting stimuli are averaged together, they hold 18% longer than the average of the normal series. In simultaneous exposures the interesting figure predominates in imagery in 47% of the trials as against 10% for the meaningless figure, whereas in check series with both figures simple, the majority of the trials yield equal images, and the images hold 4% longer in the former case. On successive exposures with the first object interesting the second predominates in imagery only .33 as frequently as when both are meaningless, while the images rise more quickly and hold longer under the former condition.

The following points in the introspection may be noted. In single exposures associations are frequent in connection with the imagery of all but the two most kinaesthetic subjects *L* and *Mt*. The figures that yield for a given subject the most associations are usually held by him longer in imagery than the other figures. With *F* there is a possible correlation between the time the image holds and the pleasantness of the associations. With *Br*, *C* and *Ms* the images tend to become the real objects represented instead of the plane figures.

In simultaneous exposures the factor of interest is mentioned by all the subjects. With three, *Br*, *Ms* and *Mt*, there is a tendency for the images to become real objects. There is frequently a change in predominance of an interesting object as the series progresses and the same object occurs several times. Toward the end of the series the images tend to be more nearly equal. This occurs with five subjects. As *Br* says, "The reason they even up in clearness is because at the beginning there is more difference in meaning. As I go along with it, the one tends to lose some of its associative value through repetition and the other tends to get a meaning. You exhaust the interest of one object and try to get interest for the other." Or as *H* states, "One object attracts the attention more at first, but after becoming familiar with it, it is easier to distribute the attention."

On successive exposures *Bz* states that "the more interesting it is the more it gets into consciousness." *Bz* and *R* have a tendency for the outline figures to become real objects in imagery. There is further a tendency with three subjects for the interest to wear off with repetition and affect the imagery. Considering the successive trials the second figure predominates more frequently toward the end of the series.

TABLE V

TABLE V
MOTOR REINFORCEMENT

Subject	SINGLE EXPOSURE				SIMULTANEOUS EXPOSURE						SUCCESSIVE EXPOSURE		
	TIME				REPORT		TIME				REPORT	TIME	
	AROUSAL		HOLDING				AROUSAL		HOLDING			HOLDING	
	Percentage of superiority traced	Difference / P. E.	Percentage of superiority traced	Difference / P. E.	Traced predominate	Other predominate	Percentage of superiority traced	Difference / P. E.	Percentage of superiority traced	Difference / P. E.	Traced / normal	Percentage of superiority traced	Difference / P. E.
Bz	—8.6	2.2	1.3	.2	95%	0%	10.7	2.2	24.4	4.9	.14	97.0	26.0
Bz											.09*	33.3	4.7
D	9.0	1.5	31.0	7.2	100%	0%	—36.2	3.4	10.8	2.0	.04*	2.6	.4
F											1.01	—62.8	12.7
H											1.00	—72.4	16.5
K											.69	—51.3	5.1
L	16.0	3.8	1.2	.3	40%	45%	—5.9	2.2	9.6	1.9	.91	—40.0	6.1
Ms											.08	14.2	4.2
R	—23.0	1.9	31.0	3.2	80%	10%	—260.0	11.1	6.5	.9	.74	—8.5	1.3
R											.42*	13.0	2.1
T											.67	300.0	23.0
Average.....	—1.4	2.3	16.1	2.7	79%	14%	—72.8	4.7	12.8	2.4	.53	20.2	9.3

* Check series; performed later.

E. *Motor Reinforcement*

The results of the experiments on motor reinforcement produced by tracing with a pencil on the table the outline of the figure fixated, are summarized in Table V, which is similar in form to the previous tables. On simultaneous exposures the subject fixated between the figures while tracing one of them. The table shows a slight average difference on single exposure between the tracing and the normal series in times of arousal, but a 16% superiority of the latter in time of holding. On simultaneous exposures the traced object predominates in 79% of the trials as compared with 14% for the other object. The images in the tracing series rise much more slowly and hold considerably longer than in the check series with no tracing. The delay of the images on the tracing series is probably due to the confusion of having in the hand the pencil with which the tracing was done, and the necessity of laying down the pencil or signalling with the other hand. On successive exposures with the first object traced the second predominates only .53 as frequently as when no tracing is done, and the images hold 20% longer on the average under the former condition.

The introspection indicates further how the tracing tends to reinforce the imagery. On single exposures *Bz* notes, "Tracing helps; the eyes go around it and the eye muscles repeat in imagery; see the images usually as enclosed spaces but with tracing I see the edge more." "Trace the triangle with the eye on the apex and it comes that way in the image." The distribution of attention in the image thus follows that of the exposure. *D* shows a similar tendency. "Image is as I draw it, e. g., imperfections in the angles I draw." *L* feels "kinaesthesis during the image, mostly in the arms." He further notes a "better control of the image when traced." *R* has a "tendency to trace the image; like eye movement, or as if the line ran around." Again, "Image comes from the tracing; sometimes forget what was shown but remember it by movement of the hand; think the tracing does not add to it except when I forget image and remember it kinaesthetically."

On simultaneous exposures the only reports of interest are those of *L*: "Try to divide attention, fixate between them and trace automatically; this causes alternation of attention between one object and the other and in imagery the figures frequently alternate."

On successive exposures *Bz* frequently reports kinaesthetic imagery in conjunction with the visual, and this kinaesthetic

imagery is of the first object. He further adds, " It helps to work the kinaesthetic and visual together; the kinaesthesis brings up the visual; it fixes the outlines better; the eyes go around more on the tracing although they sometimes do so on the normal." *D* tends to " have an idea of the first object in kinaesthetic terms while looking at the second." This tendency has been noted by *D* in other series. In the present case it is more marked on the tracing series than on the normal. With *H* the second object always appears alone. She shows here and elsewhere a pronounced tendency toward immediate arousal of imagery of the object just seen,—a marked visual perseveration. *K* notes a change from a visual to a motor attitude. " Tracing often lessens interest in looks; there is a change of attitude in some figures it rules out the bad parts while others I do not like unless I trace them." *L* finds occasionally a " motor memory of the first while looking at the second,—a thought of the movements of the hand." *Ms* occasionally reports kinaesthetic imagery in conjunction with the visual and in general " likes to trace them." *R* sometimes finds that " kinaesthetic images bring up the first object." He finds that " tracing concentrates the attention."

F. *Motor Distraction*

The results of experiments on motor distraction are summarized in Table VI. The distraction was produced by writing on the table extraneous words of three or more syllables during fixation. The word was given before the object appeared on single exposures and one second before the second object appeared on successive exposures, and the subject wrote and rewrote the word during fixation. It was not possible to test the factor of motor distraction directly with simultaneous exposures because the distraction would naturally involve both objects. The best approach to the problem seemed to be to direct the motor attitude to the objects alternately and see if in the subsequent imagery the attention would follow a similar course. Tracing one object would serve as a distraction from the other and so there would be an alternating distraction and an alternating reinforcement. The experimenter said, " Right, left, right, left " during the exposure in time with the swings of a pendulum properly adjusted, starting alternately with right and left in successive trials. The subject traced on the table the object designated, and in most cases there was time to trace it only once.

The table shows no unanimous tendency on single exposures. On simultaneous exposures with alternate tracing the images

TABLE VI
MOTOR DISTRACTION

Subject	SINGLE EXPOSURE				SIMULTANEOUS EXPOSURE						SUCCESSIVE EXPOSURE		
	TIME				REPORT		TIME				REPORT	TIME	
	AROUSAL		HOLDING				AROUSAL			HOLDING		HOLDING	
	Percentage of superiority normal	Difference / P. E.	Percentage of superiority normal	Difference / P. E.	Images—alternate		Percentage of superiority normal	Difference / P. E.	Percentage of superiority normal	Difference / P. E.	Write / normal	Percentage of superiority normal	Difference / P. E.
					Writing	Normal							
Bz	7.0	1.4	.7	.7	55%	0%	3.4	4.5	46.6	6.3	.51	—41.3	9.9
Bz											.18*	—17.0	2.1
D	—6.0	1.2	—4.6	.6	100%	0%	—3.3	.3	66.0	5.8	.30*	5.2	.8
H											1.0	166.0	15.5
K											.92	60.5	6.9
Ms											.24	84.0	13.4
R	37.0	3.2	—26.0	2.9	0%	0%	—15.7	1.3	—42.1	5.3	1.23	61.7	9.1
R											.75*	9.9	1.7
T											.97	—111.0	28.0
L	—12.7	3.1	8.0	1.7	58%	0%	—10.5	1.4	—5.2	.9			
Average.....	6.1	2.2	—5.5	1.5	53%	0%	—6.5	1.8	16.3	4.6	.68	24.2	9.7

* Check series; performed later.

alternate in 53% of the trials whereas normally they never alternate. They rise more slowly and hold longer under the former condition, but it is doubtful as to what is thus indicated,—reinforcement or distraction. In successive exposures with motor distraction on the second object it predominates only .68 as frequently as on the normal series and the images hold 24% longer on the normal series.

On single exposures *Bz* frequently writes automatically and keeps the attention on the figure. There is also a "tendency to name some of the figures when writing a hard word,—motor reinforcement to make it persist, and after the flash the vocal cords say 'semi-circle' and there is more effort put forth to get the image under these conditions." *D* states that the "writing takes away from the clearness of the image; it takes away the attention." *L* finds the "spelling automatic," and speaks of the attention as "divided between work and figure." *R* also finds that "the writing is automatic and does not distract at all even if there is a visual image of the word and the hand." "It is more pleasant to write than not to; it relieves the monotony of fixation."

On the simultaneous series with alternate tracing *Bz* is conscious of eye movements. "I keep the eyes in the direction of the one last looked at; I think the attention goes with the eye muscles; effort to keep the eyes still when the flash comes." *D* notes a "feeling as if the eyes were turning." *L* gets the image in "nearly the same distribution as the object." It may be noted that in the trials in which the images alternate, with *Bz* and *L* the alternation starts with the figure last looked at, while with *D* it starts with the other, i. e., the figure presented first in the tachistoscope. There is one exception in the case of each subject.

On successive exposures *Bz* reports, "If I write carefully it has a distracting effect." Sometimes he keeps "repeating the word during the image." *D* shows two tendencies. The table shows that the writing detracts from the second object in about 70% of the trials. But in the remainder the second object is relatively much clearer than in the normal series. *D* states that the "words sometimes take away from the first although they on the whole detract from the second." He can write automatically. Further, "Normally I get an idea of the first kinaesthetically while looking at the second, and when writing I ignore this." Evidently the writing sometimes operates as a distraction from the second object, and sometimes distracts from the kinaesthetic persistence of the first during the exposure of the second. *K* shows very slight

influence of the writing on the whole. He states, "Tracing the word seems to wipe out the kinaesthetic aspect of the first,—my whole kinaesthetic set as a real object; the movement may interfere with the kinaesthesis that normally develops; tracing seems to wipe out the perseveration of the first." Again, "Tracing does not seem to interfere with the image if I name the first object." Presumably these two tendencies balance one another in the results indicated in the table.

G. *Mental Distraction*

The results of the series with mental distraction are summarized in Table VII. The distraction was produced by performing continuous addition aloud, starting with one number and adding a second to it and continuing to add the second to the resulting sum. On the single exposures and on the successive with distraction on the first figure, the numbers were given about 2 seconds before the appearance of the figure,—instructions such as "17 add 24." On successive exposures with distraction on the second figure, the first number was given before the trial and the other number 1 second before the appearance of the second figure.[22] On the simultaneous method as on the series with motor distraction it was not feasible to test the variable directly. The subjects fixated the figures alternately making four alternations per exposure as directed by the experimenter's signal, "Right, left," etc.

The table shows that on single exposures without distraction the images hold 17% longer than when addition is done during fixation. On simultaneous exposures with alternate fixation the images alternate in 45% of the trials whereas they never do normally. When the distraction is given on the second figure it predominates about .82 as frequently as normally and when the distraction is given on the first figure the second predominates .15 more frequently than normally. The only large differences, however, are with *Bz* and *Ms*. With distraction on the first or second figure the images hold somewhat less than on the normal series.

On the single exposure series *Bz* finds the addition a "pronounced distraction." Consequently he finds that "when the adding is hard I want to shut my eyes for fear of making a mistake." He has been a school teacher and feels badly if a mistake is made. *D* simply says that the "addition takes

[22] This was to enable the subject to start promptly on the addition although not starting during the first exposure as might be the case if the numbers were both given at the outset.

TABLE VII
MENTAL DISTRACTION

TABLE VII
MENTAL DISTRACTION

Subject	SINGLE EXPOSURE		SIMULTANEOUS EXPOSURE		SUCCESSIVE EXPOSURE					
	TIME		REPORT		REPORT		TIME			
	HOLDING						HOLDING		HOLDING	
	Percentage of superiority normal	Difference P. E.	Images—alternate		Add on second normal	Add on first normal	Percentage of inferiority add on second	Difference P. E.	Percentage of inferiority add on first	Difference P.E.
			Alternate fixation	Normal						
Bz	31.0	3.0	25%	0%	.29*		—9.8	2.9	—86.0	22.3
Bz					.42	1.27	17.5	2.8		
D	21.0	2.9	87%	0%						
F					.90	1.04	—29.8	9.6	15.8	5.3
G					1.02	1.23	28.8	8.0	70.3	13.8
H					1.00	1.00	125.0	24.0	34.4	13.0
K					.98	1.08	17.6	2.5	53.0	6.0
L	18.0	3.4	66%	0%	1.03	1.01	12.0	3.1	33.3	8.5
Ms					.59	1.45	25.0	6.8	53.0	11.3
R	—1.3	.6	0%	0%	1.08	1.24	62.3	9.2	44.0	7.1
R					.84*		—17.0	2.1		
T					.92	1.00	—206.0	24.8	—157.0	19.7
Average...	17.2	2.5	45%	0%	.82	1.15	4.1	8.6	6.7	11.8

* Check series; performed later.

the attention from the imagery and makes the image less clear." *L* finds the arithmetic "a great distraction, more so than the writing." Occasionally when distracted he "gives it a good look at the end." *R* says, "If I put the attention on the adding it reduces the imagery."

On simultaneous exposures the reports are almost identical with those on motor distraction (supra). *Bz* and *D* note eye movements with the alternating images, while *L* notes the distribution of attention in the image almost identical with that in the stimulus. With *Bz* and *L* the alternation starts with the figure last looked at, and with *D* it starts with the figure that was exposed first.

On successive exposures the introspection indicates that the adding in general affords a distraction. The noticeable thing, however, in Table VII is the marked results for *Bz* and *Ms* and the slight difference for the other subjects. This result might be due to one of several causes: (1) individual differences in the actual effect of attention upon imagery, i. e., whether a conscious visual impression is necessary for the arousal of the image; (2) individual differences in the method of addition,—e. g., whether visualizing the numbers interferes with the visual impression; (3) differences in the degree of attention devoted to the addition,—whether it always occupies the focus and whether the attention fluctuates.

The first of these possibilities would seem to be ruled out by the fact that both *Bz* and *Ms* report trials in which the image appears without there having been a conscious impression of the stimulus, and two other subjects do likewise. As to the second, in a series of tests upon ability in continuous addition under visual distraction *Bz* and *Ms* show a slight loss in efficiency as compared with their normal rate, but four other subjects show the same tendency. Moreover *Bz* visualizes the numbers and *Ms* does not. The third alternative remains and a survey of the introspection tends to substantiate it. Most of the subjects give occasional reports that would indicate fluctuations of attention during the addition, or addition performed with varying degrees of attention. The two crucial subjects do not show these fluctuations. *Bz* adds with a high degree of attention. He "likes to get up to 100." He hates to make a mistake in addition. It is to be noted that in the previous series on single exposures he shows the effect of the distraction the most markedly of the subjects. *Ms* finds that "when the addition went well it attached a pleasant effect to the object and when it went poorly it took the attention from the object." As a matter of fact it seldom

went well and his general opinion at the end of the series was that he "hated it." It is probable that with these two subjects the mental state while observing the object and doing mental addition approaches more nearly and constantly to complete distraction from the object.

Thus the fact of the influence of attention upon imagery which has been more or less manifest throughout the entire investigation receives definite corroboration. Although a complete control of attention is impossible, the results give rather strong indications of the importance, for imagery, of attention bestowed upon the stimulus.

IV. Summary

A. *General Tendencies*

The preceding experiments have investigated the rôle in imagery of complexity of contour, size, length of exposure, interest, motor reinforcement, motor and mental distraction. Each of these variables was applied to a stimulus object and the effect upon subsequent imagery noted. Three methods were used in each case,—single, simultaneous and successive exposures,—with fairly consistent results. The first five variables mentioned tend quite generally to reinforce visual imagery and facilitate its arousal, and the last two have the opposite effect. If the general averages at the bottom of the columns in Tables I-VII are considered it is evident that the smallest differences are shown by all three methods for size and length of exposure. Motor reinforcement yields a marked effect by all methods, and interest also ranks quite high. The effect of complexity and motor distraction is considerable in simultaneous and successive, and that of mental distraction in single and simultaneous exposures.

B. *Individual Differences*

Average results must not be allowed to obscure the individual differences, for while the subjects nearly always show the influence of the factors in question, there are great differences in degree. Furthermore the introspection reveals that the given factors operate by different means with the different individuals.

If the results for the subjects who participated in the experiment on a number of variables are followed through Tables I-VII, it is evident that individuals vary as to the factor that most affects them. For instance, *Bz* seems most affected by motor reinforcement and least by size. *D* is most

susceptible to motor reinforcement and least to lengthening of exposure *L's* imagery is most facilitated by interest and least by lengthening of exposure. *R* is most influenced by complexity of contour and least by distraction.

In the course of the work a number of individual tendencies have been brought out. The salient points for each subject may be briefly mentioned.

Br notes the presence of kinaesthetic factors during the presentation of the stimulus, which apparently facilitates the subsequent imagery.

Bz works kinaesthetic imagery to aid the visual and in addition to central kinaesthesis actual eye movements are frequently noted. The distribution of attention during the stimulus is a great factor in influencing imagery. If one part is fixated that part becomes clearer in imagery.

C has a tendency to accentuate attributes of the stimulus such as size.

D on successive exposures has a tendency toward a persistence of the first object in kinaesthetic terms during the exposure of the second. Any distraction during the second or a shortening of its exposure tends to interfere with the persistence of the first and to detract from its subsequent imagery. Much depends too upon distribution of attention during the stimulus period.

F shows considerable play of associations with simple figures and this correlates in general with reproductivity of the figures in imagery. It is the pleasant associations that have the greatest effect.

H's most marked feature is a pronounced visual perseveration. In single and simultaneous exposures the images usually appear very quickly and exactly reproducing the stimulus object. In successive exposures the second object appears alone in imagery under all conditions, and rises quickly.

K shows like *D* a kinaesthetic persistence of the first object during the second on successive exposures. Distraction on the second militates against imagery of the first.

L reports far more kinaesthesis than any of the other subjects. The visual image is frequently filled in with kinaesthesis. In the voluntary arousal of a visual image with merely a word stimulus, he experiences great difficulty in getting a visual image at all. Kinaesthetic imagery is sometimes used to mediate the visual. On successive exposures there is frequently a motor memory of the first object during the second. The distribution of attention in the imagery follows that in the stimulus. In some cases an attribute of an

object appears in imagery although the object itself does not do so.

Ms has a great play of associations. The objects tend to become real in imagery with a very definite and complex context. This tendency correlates with reproductivity to a considerable extent. He also occasionally notes kinaesthetic imagery in conjunction with the visual.

Mt has kinaesthesis frequently in connection with the visual imagery. She feels it would be easier to draw the figure than visualize it, and there is a tendency to draw the part that is interesting.

R, after tracing an object, often recalls it for visual imagery by an actual movement of the hand. In many other instances he names the object as an aid in recalling it.

C. *Conclusions*

1. Complexity of contour of a plane figure, increase of its size, lengthening of its exposure, interest aroused in it and motor reinforcement by tracing its outlines during fixation tend, in general, to facilitate the arousal of visual imagery of that figure. Distraction by performing mental arithmetic or by writing extraneous words during fixation has the opposite effect. The results are, on the whole, most marked with motor reinforcement and with interest, and least marked with increase of size and lengthening of exposure.

2. Individuals differ in their susceptibility to the above factors. The visual imagery of some is most influenced by motor reinforcement; of others by interest; and of others by complexity of contour.

3. Individuals differ further in the means by which these factors operate. The principal points of difference are:

A. Other imagery,—notably kinaesthetic,—is with some individuals involuntarily employed to reinforce or mediate the visual. There may be kinaesthetic imagery of the movement of the hand or eyes around the contour of the object, or verbal imagery of its name.

B. Some individuals have a kinaesthetic persistence of a visual stimulus immediately after its disappearance, and interference with this detracts from subsequent visual imagery of the object.

C. Distribution of attention during the stimulus period conditions with some individuals the distribution of attention during the subsequent imagery.

4. It seems probable that the factors studied in the present experiment are somewhat interrelated and converge toward

a single factor,—the directing of attention to the stimulus object. The introspection indicates that the effect of complexity of contour and the effect of size are due primarily to motor elements. The motor aspect, in turn, is described as producing a greater concentration of attention. Interesting material is reported as arousing associations and stimulating attention to a greater degree. When the attention factor is made the subject of specific study by means of distraction during fixation of visual stimuli, the results show that, although in certain sporadic cases the arousal of imagery of the stimulus may proceed entirely involuntarily, a higher degree of attention devoted to an object generally facilitates the arousal of imagery of that object.

5. Apart from the question of "visual type," there are individuals who can reproduce a visual image immediately, and others for whom the visual is mediated or reinforced by imagery (or in some cases sensation) of another mode,—notably kinaesthetic. Grouping of individuals on the basis of such a tendency shows no correlation with a grouping on the basis of clearness of persistence of imagery.

A STUDY IN CORRELATION OF NORMAL COMPLEXES BY MEANS OF THE ASSOCIATION METHOD

By Lucile Dooley, University of Tennessee

I. This experiment in the Association Method was undertaken with a view to making a study of emotional complexes. More especially it was intended as a test of the validity of the Freudian theories in regard to fundamental complexes, if such a test could be made by means of the Word-Association Method. Through the work of Jung, and some others, the Association Method has become established as a means of "tapping the subconscious" in cases of abnormal mental states or of nervous disease. Extensive experiments have been made with normal persons also, but not, the writer believes, with the specific aim of testing for the presence of what may be called the "Freudian Complexes." To see if the Association Method could be used to uncover such complexes in normal persons was, then, one aim of the experiment. This sort of experiment has been used effectually for this purpose in the testing of hysterical or neurotic cases, in which the symptoms of complex are pronounced. While the "complex signs" in the normal individual are seldom so clear and unmistakeable it was thought that if the complexes that are emphasized by Freud were present in any degree the results of the experiment should yield some traces of them.

Incidentally the experiment was expected to yield some new data for the study of individual types, since there are still many problems along this line inviting further investigation.

II. The method pursued differed from the auditory-verbal method commonly used in that the stimulus was a printed word exposed upon a card-changer and the response that marked the reaction time was a motor response made by pressing a Morse key with the finger. This method has some advantages over the auditory-verbal method, and also some inherent disadvantages that became apparent in the course of the experiment. Exposing the printed word gives less variableness in the presentation of the stimulus than does pronouncing the word, with fewer chances of misinterpretation;

also, it allows investigation of the very interesting phenomenon of misreading. In the similar phenomenon of mishearing, occurring with the auditory stimulus, it is not so easy to determine how far the error was due to external causes and how far to psychical causes as it is in misreading. With the printed word and the card changer the method is more mechanized. Besides, this method permits the use of the chronoscope which is a more accurate recorder of time than the stop watch. The method has obvious disadvantages when uneducated observers are used, but the writer can see none that would operate with educated observers. Another point in favor of the printed word is that people are more accustomed to seeing isolated words than to hearing them, and that, therefore, the experiment is given a less unnatural atmosphere by the use of the visual stimulus. The method of the reaction is more open to criticism, as will be shown later.

The stimulus words formed a series of 154, with Jung's list of 100 taken as a basis. The number was increased considerably above the usual 100 in order that there might be at least 100 perfect reactions from each observer after all erroneous and interrupted ones were subtracted. The words were mostly substantives and almost all were of possible significance, it being thought that words significant to one observer would be neutral to another and that the proportion of significant and neutral words would adjust itself in each case. This supposition apparently was justified by the results. The words were printed in uniform type—spaced capitals—and exposed on a card changer that was connected with a Hipp chronoscope, so that the fall of the shutter, exposing the word, started the clock. The reaction was made by hand, with a Morse key, which stopped the clock. The association word was uttered at the instant that the motor reaction took place. A voice key was at first tried, with the purpose of making the word uttered by the reagent act upon the clock. This could not be made to work satisfactorily, however, so the Morse key was substituted. Eight observers, five women and three men, seven of them being students and instructors at the University, and presumably normal persons, participated in the experiment. The eighth was a distinctly abnormal mental type, being a young woman suffering from an hysterical neurosis. Before the main experiment was begun all observers were given a practice series of from 25 to 50 words so that none was inexperienced.

As the "Ausfrage" method was used, involving full introspections with taking of notes by the experimenter the experi-

ment with each individual necessarily covered many hours. With only two exceptions the work was never carried on for more than fifty minutes with a single observer on one day. The usual method followed was to have each observer for one hour each week, and as a minimum of 12 words and a maximum of 30 could be given and reacted to, with noting down of the introspection, in the hour, the experiment extended over a period of nearly four months, with all but the observers above mentioned. These two performed the experiment in three and five days, giving two or three hours at a time to the work. Fatigue effects were especially looked for in these cases, and, while present, were not found prominent.

After the series had been completed it was repeated with such observers as had time for the repetition, in order to test the evidences of complexes. Only two observers were able to complete the repetition series, while two others repeated about one third of it. The other four had no repetition. This series is therefore not treated separately, but its results are considered, along with the results of the main series, in the part of the thesis dealing with the occurrence of complexes.

There is a distinct advantage to be claimed for that feature of the method here employed that causes the experiment with each individual to extend over months instead of over one or two hours, as in Jung's method. This is the eliminating of the possibility that the association series will be dominated by a single mood, or affected by a single unfavorable condition. It is true that the conditions for each hour cannot be uniform but of more advantage than uniformity is the certainty that almost the whole range of the personality will come into play. As conditions were carefully noted at each period the effect that unusual circumstances were likely to have could be better measured when many periods of an hour each were included in each series.

As five out of the eight observers were of the visual and kinaesthetic types, associating a visual or kinaesthetic image before a word, and claiming great difficulty in getting a word as a response at all, even in the most trivial associations, these persons were permitted to give the motor reaction only, and the instructions were varied to read "As soon as another word, or a definite idea or image, comes to mind, react by pressing the key." Such a variation might be suspected of affecting the reaction time to such an extent as to make it of no experimental value. There is complete lack of evidence that it had any material effect, however, while as evidence that it did not cause any important variation in the time

there is the fact that observers of this type are at both extremes of the scale of quickness of reaction, and that their reactions are susceptible to the same physical and psychical influences, show the same fluctuations, the same relation to emotions, and can be correlated in the same manner, as the verbal reactions. There is also the fact that some of these observers finally learned to react with words and after this was fully learned as a mode of reaction the time averaged about the same as the purely imaginal reaction time. The word was nearly always a mere adjunct to the image, except where there was a clang-association, and in such cases the image connected now with the stimulus word and again with the reaction word in almost regular alternation. Clang-associations were wholly confined to the imaginal types, indicating that the verbal reaction was unnatural and forced. An advantage may therefore be claimed by the wordless reaction in such cases; namely, that the association obtained would be of the sort most natural to the observer, and would be accompanied by a minimum of difficulty. It seems probable that by this method there would be a smaller mean variation than by the verbal method, as the motor reaction tends to take place, after a certain interval, regardless of the content of consciousness, whereas, if there has to be a spoken word, there might be numerous difficulties in the way of its articulation. As a matter of fact there is no significant difference in the mean variations of the different observers, leaving out the one abnormal case. What difference there is is on the opposite side; i. e., the imaginal types show a slightly greater mean variation than the verbal types. Individual differences, to be brought out later, seem the most probable cause of this.

While it is felt that this departure in method does not invalidate the results of the experiment, it does raise some real difficulties. Because the tendency toward the motor reaction tends to fulfill itself regardless of the content of consciousness the delays caused by distraction or emotion are slighter than they might be if words were demanded. The fact that those observers who did react with words showed no greater variation in the face of distraction might well be explainable by differences of individual type. The doubt that arises from this condition of affairs affects the validity of comparisons between these two types. When the results of this experiment are compared with results obtained by Jung, Riklin, Wells, Kent, and others, moreover, the lengthened reaction times here considered significant are so much less lengthened than those of the above-named experimenters that

they may seem insignificant. Rarely does the time, in this experiment exceed 3.5 seconds, and 2+ is the commoner maximum. Nevertheless, within each individual series there is a sufficiently typical variation, though its range is small. While the time does not furnish so striking an indication of the complex as when time is more prolonged, it nevertheless furnishes a sign, since it is generally relatively longer in cases where there is reason to suspect an inhibition than in others. By this method there is left room for falsification by the observer, of course, but the reaction time, bodily movements, and general behavior, supply some check to falsification. It should be said that all observers gave the *appearance* of good faith, though of course this cannot be trusted too far. The experimenter recognizes the fact that falsification may be unintentional or unconscious.

When the experiment was about two thirds completed the draw-backs indicated above became apparent, and all observers were instructed to react verbally, no matter how much effort it cost. Some had completed the series at this time and were beginning the repetition. Some, however, had nearly completed the series and could not spare time for the repetition. There was only one from whom no verbal reactions were obtained, while others of the imaginal type gave anywhere from one tenth to one half verbal responses. This irregularity makes difficulties in tabulation of results, but the difficulties are not insurmountable. While many points that might be of interest, such as would arise from comparisons of different verbal forms, cannot be treated because of the irregularity and dissimilarity of the reactions, there is no good ground for thinking that the main objects of this investigation are rendered inaccessible.

III. The first step in correlating the results of the experiment was the determination of the association type of each observer. The preliminary experiment had shown that certain types of mental reaction were associated with high and low reaction time. A study of the typical reactions revealed the mental character of the subject.[1] Because of the greater number of emotional reactions in the main series this correlation is less definite than in the preliminary series, where no words designed to arouse complexes or emotions were found. Still, a relation between the average reaction time and the mental type is discernible. This study of reaction-type neces-

[1] Reported before Southern Society for Psychology and Philosophy at Atlanta, December, 1913. See "Proceedings of Southern Society," etc., reprinted in *Psychological Bulletin*, February, 1914.

TABLE I

Correlation between time and association type

Observer	No. of reactions counted in averages	Av. seconds	Median	M. V.	Formal Type			Reaction Type	Content Type				General Type
					Co-ordinate	Sub-ordinate	Supra-ordinate		Emotional reaction	Egocentric	Common	Particular	
*R.	144	*.647	*.577	.210	17 Av. time .827	127 Av. time .754	0	Vis. Im., clear cut, few details or additional tendencies not verbal except when forced.	16¼% .831	10% .663	13½% .876	86½% .651	Concrete, personal reference, occasionally emotional, non-self-conscious, few complex signs.
H.	136	.871	.830	.227	16 Av. time .864	119 Av. time .921	0	Vis. Im. and clang words, few details, but additional associations.	27½% 1.164	40% .828	5% 1.830	95% .874	Concrete, intellectual repressed emotion, personal reference, unconscious of comp. signs.
Be.	143	1.021	.925	.344	19 Av. time .748	107 Av. time 1.173	17 Av. time .929	All sorts of imagery, kinaesthetic predominant. Words used as names for images.	35% 1.462	8% .923	88½% 1.01	11½% .925	Concrete, aesthetic, emotion, richly imaginal. Complex mildly pleasurable.
K.	150	1.05	1.013	.249	75 Av. time 1.047	72 Av. time 1.212	6 Av. time .926	Verbal, automatic, few images, few additional associations.	17% 1.316	4½% 1.474	99.4% 1.014	.6% .738	Abstract, intellectual, repressed emotion, many complex signs which are unconscious.
S.	150	1.089	1.037	.266	0	150 Av. time 1.089	0	Vis. Im., clear and detailed, no words, meanings.	24% 1.717	7½% 1.085	73% 1.048	27% 1.126	Concrete, emotional, non-self-conscious, complex signs conscious.
O.	142	1.14	1.076	.274	116 Av. time 1.136	16 Av. time 1.528	1 Av. time .865	Verbal, automatic, with frequent thought processes.	20% 1.446	2.6% 1.511	97% 1.028	3% 1.424	Intellectual, somewhat emotional, logical, complex signs conscious.
Ba.	150	1.363	1.2	.382	6 Av. time 1.384	135 Av. time 1.472	0	Vis. images, detailed and definite. Words only names, meanings.	23% 2.647	39% 1.364	18% 1.451	82% 1.201	Concrete, self-conscious, moderately emotional, complex signs, often conscious.
T. Abnormal	136	1.788	1.612	.580	105 Av. time 1.012	31 Av. time 2.012	1 Av. time .515	Verbal, with an effort, frequent visual and auditory images, frequent affective tone.	39% 2.816	10% 1.743	70% 1.767	30% 1.923	Concrete, emotional, slightly self-conscious, many complex signs which are conscious.

* R. is suspected of reacting prematurely, making time too short.

sarily precedes an examination for complexes, as the manner of exposing a complex is obviously not independent of the observer's natural association habit.

The correlation between the average and median reaction times, and the reaction type of the observer is brought out by Table I. The commonest type of reaction is by visual image, with the association word as a mere adjunct, oftenest a name given to the image, when it is not omitted entirely. Only two, K and O, responded easily and naturally with words. The others did so with effort, often gave clang associations, or variations of or additions to the stimulus word, and claimed that the image was always first in order and that it was the essential part of the association. No generalization can be made as to the relative quickness of the verbal versus the imaginal type. The imaginal types stand at the beginning and at the end of the scale,[2] while the verbal automatic types are fourth and sixth in order.

The observer holding fourth place had very meagre associations, introspection frequently showing nothing beyond the word. Perseveration was of fairly frequent occurrence, and evidences of unconscious inhibition were present. The observer in sixth place had frequent thought processes though few images. This observer was cognizant of the purpose of the experiment, therefore his associations cannot be placed altogether on a footing with the others. Allowance is made for this fact in the analysis of complexes—but this knowledge on the part of the observer has less effect than might be expected. As a rule any thought of connection with the experiment was a *secondary* association, while the first was, like those of other observers, a naïve response. The main effect of this foreknowledge is seen in the reaction time. The attitude was one of expecting "significant" words, and this often prolonged the time when no emotional complex was present. Other vitiating factors have been noted, as far as possible, in all cases, and any reactions that were suspected of being affected by fatigue or physical disposition are excluded from the tabulation. The reactions of one observer which took place on a very warm afternoon have all unusually long reaction time, so these are excluded from general tabu-

[2] Observer R, who stands first in Table II, as the observer who has the lowest average time, gives some reason for suspecting that his reaction time is in reality too low. He may have reacted before an association came. His quantitative data will be starred wherever it occurs, in order to show that it is questionable. In other than quantitative aspects his reactions are entirely valid, and will be treated as valid.

lation, though they are not altogether disregarded. Whenever conditions were unusual the results were scrutinized carefully and compared with those obtained under normal conditions and where differences were apparent the former class of results were not accepted as of full value, though they still might be useful for determining some points. Whatever examples of associations are given, and whatever conclusions are drawn, in this thesis, are taken from those results only which are free, as well as the experimenter can judge, from vitiating influences.

Though no direct correlation is apparent between the imaginal and verbal associations and the reaction time, there is a correlation between the time and the *richness* of the image, or the profusion of images. Those of imaginal type who had images with few details, and with no personal meaning attached, have a low reaction time. Those who get clear cut and detailed images, with personal associations or frequent affective tones, have a high reaction time. Associations in a subordinate or predicate relationship to the stimulus predominate in the imaginal type, while co-ordinates predominate in the verbal type. Supra-ordinates are of rare occurrence in both. So far as the experimenter knows this correlation has not been observed in any previous work with the association method. How far it holds good must be determined by experiment with a larger number of individuals. The subordinate, or predicate, type, indicates, in the cases here studied, a concrete type of thought, while the co-ordinate type is rather abstract. The latter has a shorter reaction time than the former, when emotional and significant reactions are excluded.

There is some relation apparent between the egocentric type of association and the time, as contrasted with the less personal type. With the exception of observer H, who has a very low reaction time, a large number of egocentric reactions accompanies a high average reaction time. The introspections reveal the degree of *self-consciousness* also, and this bears a direct relation to the reaction time. Observers Ba, K, H, and T, are usually self-conscious, while the other four are less so. Observers Ba and H frequently saw themselves in the picture brought up in an association.

In general it may be said that a low reaction time characterizes common, non-self-conscious associations and abstract types of thought. This is true when " complex " reactions are excluded. High reaction time characterizes the egocentric, self-conscious, and concrete association types. When emotional reactions are ruled out this correlation becomes definite.

As in most experiments of this sort, individual differences cause many exceptions to be made to almost every general conclusion that one may attempt to draw. Nor are the individual traits revealed the least interesting and important results yielded by such an experiment. The discovering of the individual character by means of the experiment seems in itself worth while, and suggestive of practical application of the method.

A most striking and important difference, and one that has been fully treated by Jung (10, 11), is the difference between the normal and the abnormal observer. One abnormal observer, a young woman suffering from an hysterical neurosis, was included in this experiment for the purpose of making the comparison at first hand. The greater part of the published material on complexes deals with abnormal cases, and the experimenter felt the need of getting experimental evidence on her own account for the difference—or rather the exaggerations—of the abnormal type, when compared with the normal, in order to avoid misconceptions. The abnormal observer was a typical neurotic, not an extreme case. The abnormal *exaggeration* of various association phenomena is in her case fully evident. She shows the highest average time, and also the highest single reaction time. Her average time is 1.788, which is more than 400 sigma in excess of the next highest. Her highest single reaction time is 8.487, while the nearest approach to this by any other observer is 4.958. Five of the normal observers never exceed 2.880 as a maximum. This observer frequently showed difficulty in obtaining an association even when no complex was in evidence. When a complex was struck emotion was much more intense than in any of the normal observers though some of the latter showed a greater number of emotional reactions. The abnormal observer showed frequent inhibition and "blankness" followed sometimes by a sense of complete helplessness and despair. This was once strikingly described as "a feeling as if I were in a burning theatre and could not get out." The feeling of helplessness grew until she finally reacted (by pressing the key) in order to end it. The neurotic patient exhibits the phenomena of inhibition and emotion in much more marked degree than any of the other observers. Infantile associations were more frequent and more important in this case than with the normal observers, with whom, indeed, they could seldom be detected. The principal differences between the normal and the abnormal types are shown in Table II.

TABLE II

Observers	Normal							Abnormal
	Ba	Be	H	K	O	R*	S	T
Number of infantile associations	4	2	5	0	0	5	5	9
Number of marked inhibitions	11	4	4	6	16	8	9	16
Number of cases of painful effort	6	1	3	1	3	2	6	13
Number of cases of marked emotion	6	6	3	5	8	7	9	18
Number of failures to associate	6	0	1	0	7	4	4	11
Number of failures to make reaction	0	0	0	0	1	2	0	5
Highest reaction time	4.958	2.880	2.014	2.23	2.5	1.958	3.2	8.487
Lowest reaction time	.572	.338	.331	.469	.559	*.347	.397	.582
Mean variation	.382	.344	.227	.249	.274	.210	.265	.580

* This marks the observer whose reaction time is suspected of being too low.

A difference that cannot fail to be important to an investigation with the end in view of studying complexes is the sex difference. The average of the median times of the men observers and of the women observers is exactly the same, .951, if the neurotic patient is omitted from the woman's list. Again, here, the number is too small to permit of generalizations, but it may be said that were it not for the average of one man who gives some reason to suspect that his association time is too short—that he reacted before an association really came— the average of the men would be larger than that of the women. One male observer who was unable to complete the experiment, and whose results are therefore not included, was among the long-reaction-period types, and if his results had been tabulated with the others the reaction average for men would have been noticeably higher than that of the women; the number of normal observers of each sex would have been equal also, as was at first intended. Other experimenters who have published results have almost uniformly found the time of women to be longer than that of men, but Wells (19) pertinently suggests that this result was

very likely influenced by the fact that the experimenter was a man, which circumstance might give rise to many more inhibitions in the women. In this experiment the experimenter was a woman, which may have had an influence in raising the average of the men. The mean variation of the men is greater than that of the women, which fact is in line with the foregoing supposition, though it would be unjustifiable to assign the circumstance of the experimenter's sex as the cause of this.

The sex differences found may be summed up as follows: Median time for each .951, but with reason to believe that the men's median should have been higher; mean variation for men, .289, for women, .271; egocentric reactions for men, 17.2%, for women, 14.9%. Men have 42% common associations, 58% particular, 20% emotional, 26⅔% "significant," 7.7% inhibited, 64% predicate, 25.9% co-ordinate, and .06% supra-ordinate. Women have 66% common associations, 34% particular, 25% emotional, 23% significant, 3.8% inhibited, 74% predicate, 18% co-ordinate, 3⅓% supra-ordinate.

Another factor that is expected to play a part in determining individual differences is that of age. As age increases repressions should increase, associations become less personal and more standardized or conventionalized, and complexes become more clearly marked. But here again individual variations of character make it difficult to generalize. Perhaps *mental* age, or better, degree of sophistication, if these could be determined would furnish better criteria. The ages ranged from 22 to 38, and as the years of the twenties and thirties are apt to be fullest of emotional experience there should be room here for a distinct progression. There is such a progression although it does not proceed with regularity. Cultural differences are more apparent, and these modify the age differences, but they cannot be tabulated in the same way, for obvious reasons. It is found that the younger give, as a rule, more egocentric reactions but that the middle grade have more significant and emotional associations, excepting the abnormal subject, who was among the younger. The older ones have rich and profuse associations, with less personal reference.

Those who have the habit of imaging naturally have great difficulty with words that do not suggest an association capable of being imaged. Abstract and emotional words may thus be met by a delayed reaction which has a cause quite outside the ideational content of the word. The verbalizers have no such difficulty and may respond to abstract words with greater ease than to concrete and simple ones to which they cannot readily find an opposite or synonym. This point also brings

out the fact mentioned by Wells (19), that few " free " associations are really free when in an experimental series. They tend to become " controlled," that is, the observer sets up a certain form of response for himself to which he unconsciously tries to conform. In determining the ' complex ' value of a reaction these peculiarities of individuals must be taken into account. The verbalizers also have trouble with a reaction word of two or more syllables, and with one that is a different part of speech from the stimulus word—in short, with any response that does not fit into their customary method. When the imaginal type gives words he feels none of these difficulties because the words mean much less to him. The egocentric type likewise hesitates over a word that does not recall a personal experience. There is a sort of perseveration of the *mode* of response that is not altogether dependent upon the observer's mental character. It depends partly upon the mode with which he starts out. The experimenter may be able to change this mode by suggestion, and the new mode thus set up soon becomes habitual.

The obstacles to getting exact correlations and drawing definite conclusions that have been mentioned are probably present in the most extensive and carefully performed experiments almost as fully as in this attempt. The arbitrary uniformity of the response would not really obviate the difficulties involved here in the discrepancies between imaginal and verbal types. The writer is inclined to think that the fundamental differences in these two types have not yet received discriminating consideration. Those who were imaginal in their thinking would have the same difficulty in finding a verbal response that the observers in this experiment had, and the result would be a prolonged reaction time because they are allowed no alternative to a verbal reaction. On the whole, making allowance for difference in method, the results found here as to mental types, age, and sex, and as to the rôle of external influences, do not differ materially from the well known conclusions of Jung and Riklin, Wreschner, Ziehen, Wells, and others. That a great part is played by emotion is axiomatic. With Ziehen (22) we find that unpleasant emotion has the greatest retarding effect, while pleasurable emotion so facilitates the response as to bring the time below the average. Aschaffenburg (1) has found that fatigue and distraction increase the tendency to clang, irrelevant, and perseverating associations, and this experiment corroborates his assertion. Lipmann (14) maintains that this fact is not a disadvantage in investigating complexes, as it actually means

that repression is lessened, that inhibiting power is lowered, and that the complexes have a freer outlet. The data of this experiment are not without confirmatory evidence for this assertion. Still, in analyzing the experimental data with the purpose of discovering the emotional complexes that may be present, all such factors as fatigue, distraction, interruption from outside, and the physical conditions, should be given full weight as interferences. The central fact that makes the association method of value is that the observer reacts toward the word in some measure as he would react toward the actual situation that the word represents. The extent to which he actually does identify the mere word with a situation is often surprising to one not initiated into the mysteries of the association experiment. To some word of disagreeable import, for example, he reacts quickly, shuddering, without waiting to get a definite association word " because he wanted to get it over with and thought the reaction would end it," which is, perhaps, equivalent to turning tail and taking flight. It is this attitude toward the words used in the experiment, which quickly establishes itself in every observer, that causes the centrally aroused processes to be generally stronger than any external interferences.

IV. Having cleared the ground by the foregoing discussion of types, differences, and general reaction-characteristics, we come to the main part of our inquiry, namely, How are complexes indicated by the reactions collected? There are complexes present, as has been hinted already. How these are determined, what evidence for them is accepted, and what is the general significance of those found, also what their particular significance for the Freudian Theories, will occupy the remainder of the thesis. No complex is catalogued that is not indicated by more than one ' complex sign,' and as a rule more than one reaction will be required to establish a single complex. The ' complex signs ' considered as indicative of complex are here enumerated and described.

1. The quantitative indication of unduly prolonged reaction time is the first to be noted. Jung states that the excess must be at least .5 seconds in order to be significant. His average reaction time is 1.5. Some experimenters say that the smallest increase to be considered is 1 second. It depends upon the average or normal reaction time of the reagent. As has been pointed out in the discussion of the method, the reaction time is shorter when the stimulus is presented to the eye and the effective response is made by hand, with an instrument of such accuracy as the chronoscope, than when the stimulus is

auditory, the response oral, and when the stop-watch is used, which instrument involves the experimenter's reaction time as well as the observer's. The gross average of all the observers in this experiment, excluding that one who was suspected of reacting too quickly, and also excluding the abnormal subject, is 1.013. It seems fair, then, to count any increase exceeding .3 seconds as possibly significant, provided that there are other supporting evidences, that is, some of the other 'complex signs' listed below. On the other hand, the striking of a complex is not invariably signalized by lengthened reaction time. Pleasurable emotion may quicken instead of delay. Likewise, unless there is an effort, conscious or unconscious, at repression, the time may not be very much lengthened. The prolonged reaction time, then, cannot be taken as the invariable sign of a complex. It is only one among others, and may be lacking. A very short reaction time may be as truly a sign of complex as a very long one. One observer responded to *dream* by instantly pressing the key,—time .206!—, with no consciousness of her mistake, but the significant introspection, "I thought, 'Other people dream, but I don't.'" Such shortened times as this are not included in the tabulation, but they cannot be overlooked as complex indicators. Even when an association is given, and no error can be detected in any part of the response, the time may be very short. An observer who had an obvious "In love" complex responded to *bride* with a time of .363, and with the trivial associate *groom*. This, however, was in the repetition series. When *bride* occurred in the first series the response was signalized by length of time and by a significant association. It is not unusual for the response to go to the opposite extreme when reproduction is tried, the first response having been significant. Jung (10) has observed that the subject is seldom able to reproduce a "complex" association.

2. Perseveration. Sometimes there is no apparent connection between the stimulus word and the reaction word, yet the latter is used, not once only, but several times; also, it is used neither consecutively nor at regular intervals. This is perseveration, and if it is well marked, if the word is usually irrelevant, if the stimulus words are of a significant sort, and if the reaction time is significant in any way, it may generally be taken as a sign of complex. An example is the response *hope*, given to the following stimulus words, friendship, master, pity, wealth, sin, victory. In each instance there was another complex sign present, sometimes more than one. If the perseverated word itself

occurs among the stimuli it is pretty sure to bring a significant response. The exact interpretation of this would depend somewhat on *where* the word occurred, whether before or after the perseveration began.

3. Vacuum, or blankness of mind. This, of course, cannot always be taken as a complex sign. It may occur if the word is difficult to understand, if it seems remote to the observer, or if it follows a word of a very different import (although, as a rule, unless some unusual reaction has just taken place, words are not affected by preceding words, and as a consequence of the method here employed there is plenty of time for the effect to die out before the new one comes). Inattention, and distractions from the outside may also induce blankness, as may fatigue. If none of these factors are present, and if there is some other complex sign as well, vacuum may be taken as an indication of complex. Example: *part,* time 2.870, introspection—" Could think of nothing for a long time. Finally a vague image of people taking sides, seemed to be women, maybe suffragettes." This, when analyzed, was found to be related to one of the dominant complexes of the subject.

4. Irrelevant, or unmeaning response. This may take two forms, (a) the qualitative relations between a stimulus and a response are of unmeaning character, (b) the response itself is without meaning—i. e, clang associations. The second form is less common than the first. The introspection sometimes reveals a relevance that would not otherwise be apparent, even to the observer himself. An example of the first form is *book—tree* (perseverative). An example of the second is *dear—mear.*

5. The phenomenon of misreading must be taken as significant if there is supporting evidence of complex, or if no cause is to be found in the printing of the word, the lighting, etc. Thus one observer, after having used *tree* as a perseverative response five or six times, misread *tree* as *thee,* and associated *me,* when *tree* occurred as a stimulus word; as the word was clearly printed and as no other observer had any difficulty with it, save one, who also presented evidence that *tree* touched a complex, this case of misreading is interpreted as a complex sign. Analogous to *mis*reading is inability to read. One subject had great difficulty in reading *marriage* (a word reacted to significantly in every case) and said that the letters seemed to be one above the other and jumbled together. The word was, of course, clearly printed.

6. The failure to get an associate will usually occur with No. 3, " vacuum," but not always. Sometimes there is a

rush of ideas but nothing articulate. Of course this failure may be due to some of the causes mentioned in the discussion of individual differences and reaction-habits, or it may be due to the strangeness of the word. There are no really uncommon words in the list, however. We might venture to say that every one of them would be met with in the reading of a single issue of a daily newspaper. When no "harmless" explanation will satisfy the case, then the failure may be taken as an indication of complex. The observer's own account of the reason for the failure is by no means trustworthy, even though offered with full sincerity. An unmistakable case was the word *abuse*, when no word came, and no idea of any sort was fully conscious until the observer finally pressed the key, fearing lest the weight on the clock should reach the bottom, while she remained passive, and so jar the mechanism. It was therefore not a true reaction, and the time is not so long as it would have been had she waited for an association. After the reaction came a picture of a horrible looking man, who was thought to be *abusing* someone. The time elapsing before the clock was stopped was 8.487. This observer had an experience in childhood with which this image was remotely connected. She had now an exaggerated dislike, amounting almost to hatred, of men, as *masculine*, as part of a strong sex-complex.

7. Failure to give the motor reaction. In some few cases the association is so absorbing, because of its strong interest or its affective tone, that the motor reaction is inhibited or, what amounts to the same thing, forgotten. Such instances are very rare, and this infrequency of occurrence gives them the more importance. The *habit* of response by the motor reaction is usually so firmly fixed that it tends to take place after a certain interval, even though no associate has been obtained and though the mind remains a blank, and all other activity is inhibited. This tendency, by the way, has much to do with the fact that there are relatively few very long reaction times. When this habitual action is inhibited we may be pretty sure that there is a strong reason. One such case is in response to the word *knight*. The preceding word was *lady*, and this had recalled a romantic picture, from a fairy tale, that related to a very common complex, exposed by other words as well. When *knight* came the observer exclaimed enthusiastically, "Ah! the Prince! the Prince! the Prince!" and quite forgot to press the key. She explained that "she was so delighted that the prince came in just after

the lady." Such excess of feeling, however, must have meant a reinforcement of the association, due to a complex.

8. What might be a variation of the failure to associate is the *surrogate response*. The observer cannot find an association word, is conscious that the word likely to come is one he would wish to suppress, perhaps, so glances around, and names some object in the room, or, possibly, something connected with the dress or the person of the experimenter. Since the giving of objects near at hand is very unusual, the associative thought nearly always running in paths remote from the present time and place, such instances are likely to have a significance.

9. Embarrassment, evidenced by a nervous laugh, or by much hesitation and stammering, is a universally recognized sign. A good many instances of this occur in these experiments, sometimes with words that are obviously significant, such as *marriage*, sometimes with words that seem trivial and which are responded to in an unusual manner by only one observer. An instance of the latter sort was *key*, with no reaction word, but a visual image of a big brass key, associated with a brown door, then complete blankness of mind. The reaction was accompanied by a laugh and a slightly flustered manner.

10. Conscious emotion is not always a sign of complex, and on the other hand, a complex may be exposed without any accompaniment of conscious emotion. Cases of emotional reaction are numerous, as some of the tables given in the earlier divisions of the thesis show. They are more likely to be complex indicators when the observer is unable to account for the emotion. A mere sense of pleasure, or of aversion, detached and impersonal, is not necessarily, or often, a complex sign, or so the correlation of these results indicates. One example where emotion was strong, where a complex was undoubtedly present, and where the subject fully understood her emotion is found in the association *child—mother*, with a reaction time of 1.752. The introspection contains this statement, "I had a feeling that I can't quite express when I saw the word *child*. A feeling that I always have when I see a little child—half pleasant, and yet it hurts, so not pleasant in a way. A feeling as if one would like to cry." This complex had been analyzed before, and the repression was largely freed. This might account for the fact that the time was not very long.

11. The association word may be the chief indicator of the complex. It may be related to the stimulus word in a way

that reveals a significant background or it may indicate an inhibition or a state that is *almost* a vacuum. Few words of very significant meaning occur, and one may surmise that this is due to successful inhibition. A trivial associate, accompanied by a delayed reaction and signs of confusion and embarrassment may indicate that a more significant word was intended, but that it was repressed. Sometimes the introspection reveals that the reaction word given was not the one intended. Such was *fall-down,* when *down* was acknowledged as not the word meant—the real word, however, did not emerge fully into consciousness—and as trivial, and inadequate to the meaning, which was moral, and was admitted to open a complex. Clang associations, such as *fall-call* may be significant in like manner. An incomplete response may indicate a complex, as for instance *seed-peh,* when *pod* was the word intended, and represented by its initial sound, yet pod was not related to the thought tendencies present, which took seed as symbolic. This inappropriateness may have caused the stopping of the pronunciation of the word. A reaction word that merely adds a suffix to the stimulus word may be a substitute for a significant word, as, for example, *ridiculement.* This, in addition, is a nonsense word. Another striking one is *bride-bridle.* An anagram, or near-anagram may even be used, as *bride—bird,* the subject saying that the letters of the stimulus word rearranged themselves into *bird* and she was unable to think of anything else. The tendency to add such suffixes as *ly* and *ing* increases with fatigue, and unless we accept Lipmann's theory, cited on page 130, we cannot regard these as significant when fatigue is present.

12. Last of complex signs to be mentioned as occurring in the course of this experiment is the post-critical response. This is the case when a word insignificant in itself has an inhibited or delayed reaction because of the effect persisting from the word just preceding it. Even when the words were given fully two minutes apart, as they usually were in this experiment, allowing time for the introspection and for taking notes, this phenomenon is occasionally observable. In the majority of observers, for example, the word *new* called forth a delayed response, or perhaps a failure, yet the introspection revealed nothing significant. When it was noted that the word *new* followed *sin,* which nearly always called forth an unusual reaction, and when it was taken into consideration that the train of thought in the after-period might be even more emotional than at the first apprehension of *sin,* an explanation of the unusual reaction to *new* was found.

While it is to be expected that complexes will be found to be individual affairs, depending for their character upon the history and personality of the individual, yet it is well known that some complexes of feeling are universal.

The word *complex* is not here used in its most limited sense, as it is by Freud and Jung, to denote a group of emotionally toned ideas completely repressed into the unconscious, and having a sinister effect upon the mental life of the individual, but rather in the broader meaning given it by Hart in his "Psychology of Insanity" (9). Hart says "A complex is a system of connected ideas with a strong emotional tone, and a tendency to produce actions of a certain definite character" (p. 51). It has been questioned whether this view of complex does not make it really nothing more than what is known as "interest." It is taken by the writer to be something more than, and different from, mere interest, in that it bears a stronger emotional tone, in that it more definitely determines action, and, chiefly, in that it is a system of ideas and an emotion which the individual would conceal from others, although it is not necessarily concealed from himself. It is very likely to be below the level of conscious thought, but the subject may, on the other hand, be fully aware of it, or aware of it in varying degrees. Such groups of ideas tend naturally to gather round the great facts of life, such as birth, marriage, and death. *Complexes*, in the sense just given appear in connection with words relating to these great facts in every observer tested by this experiment. These complexes I have styled "Common Complexes." If the number of persons tested had been large enough to be representative they might have been termed "Universal Complexes." A list of common complexes is given below, with the complex signs shown by each observer with four of the clearest cases. Of course no single word calls out equally strong indications in every observer. On the other hand there are complexes that seem common to all but are not aroused by the same words in all.

Examples of common complexes:

1. Marriage.
   - Observer a. Inability to read, delayed reaction, inappropriate image.
   - Observer b. Perseverative idea of *two* people, solemn emotion, very short time.
   - Observer c. Difficulty in reading, clang association, false reproduction.
   - Observer d. Hesitation, time under-estimated, word *tie* automatically.

Observer e. Confusion, a rush of emotional tendencies. Association word *birth,* slightly inhibited. Time long.

Observer f. Embarrassed laugh, hesitation in speaking, no association voiced. "Don't know what I thought of." Clang association when series was repeated.

Observer g. Embarrassed laugh, no association, mechanical motor reaction, time short.

Observer h. Time long. Felt anxious to get a word quickly, "to get it over." *Divorce* came with a distinct sense of relief, as if this were a way out of the trap. (This from the man hater.)

2. Dream.

Observer a. No word, impossibly short time. Thought "Other people dream but I don't." Unconscious of error in reaction.

Observer b. A long blank. Time 4.958. Finally a connection with fiancée, with unusual features in the association. Thought of pressing the key and saying he could think of nothing. The inhibition of association was nearly successful.

Observer c. Prolonged reaction, no definite association, a confusion of thoughts, finally settling to recollection of one significant dream.

Observer d. Slightly prolonged. Word *ghost.* A visual image, which is very rare with this observer. The reaction seemed utterly irrelevant, according to the observer.

Observer e. No reaction word, sense of familiarity. A beginning of a word but it was inhibited.

Observer f. No association, no motor reaction, but a vague idea of dreams in general.

Observer g. Hesitation, blankness, Calpurnia's dream thought of, but no word or image.

Observer h. Premature reaction, without any association. The feeling that this was something familiar and intimate and that therefore the key must be pressed at once.

3. Sin.

Observer a. No associate, a vague reference to "Vision of Sin" and a tendency to say *Longfellow,* though he knew it was *Tennyson.*

Observer b. Spelt word, s-i-n. Distinctly unpleasant feeling, and a groping to get hold of an abstraction. In after period it was thought of as "something you ought not to do." Post-critical reaction.

Observer c. Blank, then rhyme, post-critical rhyme again, and an irrelevant visual image.

Observer d. Redundant response, two words given, both perseverative, both irrelevant. Prolonged time.

Observer e. *Death* as associate, automatic, with no consciousness of connection. After reaction came quotation "Wages of Sin is Death." Post-critical reaction to succeeding word.

Observer f. Clang association, post-critical reaction, one surprising to the observer.

Observer g. The Welt-Schmerz complex indicator, which will be treated under "Individual complexes."

Observer h. Complete inhibition, no reaction. The observer could not understand the inhibition, as it was a familiar idea, "I've been to Sunday School. . . . Everything you do, almost, is a sin."

4. Death.

Observer a. Prolonged reaction time, blankness, a gradual dawn of a visual image connected with brother's death. Non-conscious emotion.

Observer b. Word *youth*. vis. im. of a young girl dead. A feeling that death was hovering all around, and that *youth* made it sad. Long reaction time.

Observer c. Laughter, reaction word *cold*. Feeling of aversion. Faint visual image of tall figure with scythe.

Observer d. Clang association, *dearth*. No feeling. Prolonged reaction time.

Observer e. Reaction word *head*, and sense of its inappropriateness, "All set for a quick reaction, but it was inhibited."

Observer f. Automatic reaction, time .222! A long blank, then vis. im. of a grave yard, and strong emotion. "A shaky feeling,"—"it cast a damper over my whole state of feeling. I don't like to think about it." In repeated series a false reproduction, a solemn, awed feeling, quite strong.

Observer h. Word not understood, so no reaction. This was one of a dozen words given orally. There had been no difficulty in understanding any words, except one other that was also suspected of opening a complex. This observer began to suffer from an hysterical neurosis soon after her father's death. She had nursed her father for eight months.

Other words that are accompanied by one or more complex signs in all or most observers are: coffin, choice, bride, ridicule, friendship, child, quarrel, contempt, expense, size, friend, mate, separation, abuse, delight, prison, pity.

Some words that are in every case met by prolonged reaction time, thought to be due to other causes than *complex* are: green, blockade, custom, water, coat, new, kitchen, suspense, dwarf, pamphlet, contentment, masquerade.

It is not possible to say that none of the second list refers to complexes. It is only said that the evidence is insufficient. Likewise, it is not positive that all in the first list are complex indicators, but the evidence points that way. At the end of this paper will be found a graded list of words, giving the number of observers that reacted significantly to each.

Words are not the most reliable tests, when treated in the manner suggested above, though this is the way most investigators who are not, like Jung, seeking to make diagnoses, treat them. The same word may open different complexes in different persons. On the other hand there are complexes

that are common to all, or to nearly all, though they are not reached by exactly the same word in each case. Besides the fundamental complexes already noted, there is the *wealth* complex, common to four of the eight, shown by some or all the words relating to money. The *travel* complex shows some traces in all, strongly in some, when almost every word relating to travel or movement is responded to by the perseverative word *go*, or by a pleasurable emotion. The *ambition* complex, signalized by such words as victory, goal, captain, etc., shows traces in most observers. Words pertaining to out-of-doors, and particularly such words as garden, seed, plant, bring out some strong traces in every observer though it is not the same words that are active in every case. It is quite possible that totally different complexes are touched by these same words. The motherhood complex is evident in three out of five women, and the fatherhood complex in two out of three men. The "*love*" complex, which is not quite the same as the marriage complex—or is not necessarily the same, as the love complex usually arises in connection with a definite 'affair,' whereas the marriage complex exists, either repressed or conscious, in all, without any external object or encouragement,—is clearly evidenced in all the men, but only equivocally or not at all, in the women. This is altogether in accordance with the laws of society, and, we suppose, with the laws of biological evolution. As an example of how results are grouped to obtain clear evidence of a complex one of the love complexes will be given here, because it illustrates the method very clearly, and also because it is quite "harmless," even to a Freudian.

The first word that brought a significant reaction relating to this complex was the word *dream*, already cited in another connection. A very long reaction time, 4.958, an inhibition that threatened to retain the mastery, and difficulty in relating the experience were complex signs. The introspection showed that the word recalled a telephone conversation with a young lady, and afterwards, through later associations the experimenter learned that this conversation was connected with his fiancée. Then came *snake*, with a long reaction time. The image of a *young lady* who is afraid of snakes was all that occurred. In the after period came full recollection of a scene with this young lady, wherein a snake was concerned. Then came *marriage*, which has already been given. There was inability to read the word at first, *as the letters seemed one above the other*, and jumbled together. While we have distinguished between a love and a marriage complex it seems

fair to include this word here, as the love complex was so very much in evidence that it would surely have absorbed the other. Then *dear,* association word *deer,* with a laugh, and "knew it wasn't appropriate." *"Knew at once that dear could bring no associate."* Time very short (.678). A little later the word *friend* brought the following reaction. First, blank (conscious of inhibition), then visual image of a young lady. Consciously trying to find a *person* as an associate. Knew all the time that the intention was toward a person but had to wait for the image to come, time, 1.777. Some fifteen minutes later, on the same day, the climax came with *kiss.* There was a premature reaction—(protective?) but no association given at first. Then the observer began to tell slowly, with evident difficulty, what the word brought to mind, interrupting himself to say, "You ought not to put up such a word." It brought up an experience with the "Young lady." He admitted that this association came at once, that he tried his best to think of something else, but could not, so gave up and confessed. After a few indifferent words came *bride* and this at once aroused the image of the young lady, and all the emotions of the former experience. He "tried to keep it off, saw it was coming, couldn't stop it." The time was longer than the time for *Kiss.* When these words occurred in the repetition series there was no reaction, no distinct recollection of how he had reacted before, but a recollection that "he had had trouble with the words." A few minutes later came *lady* and this aroused the same association, but much more quickly, with no struggle, no resistance, little emotion, and the image was fainter also. The wave was receding. When the word *choice* came, after seven indifferent words, there was complete inhibition for a time, consciousness of this inhibition, and then it resolved itself into making a choice of music—looking over sheet music. The time was one of the longest given by this observer, 2.956. Other words that may have related to this complex but have not very clear complex signs are woman, mate, month, misread as *moth,* butterfly, blush.

The method employed here is obvious, as the complex was obvious. All that was necessary in order to establish this complex was to note what words brought the same associate, although there was seldom an associated *word,* as this observer was of the visual type, and to examine the reactions and introspections for complex signs, which are sufficiently marked. Few other complexes found are quite so obvious, but the general method is the same for all observers who react with clear images or full-fledged thoughts. Such give few verbal

indications. For the type that reacts with words, automatically, with very few images and little thought content, a different method must be employed. Perservation furnishes a principal road of approach here. The perseverated word may be an arbitrarily chosen word used on every occasion when it is desirable to cover a complex—and this concealment may be unconscious—or it may be a word that expresses the emotion which the complex arouses, and so not truly irrelevant, though it bears no external relation to the stimulus word. An instance of the former sort may be *tree*, used to respond to ten words, about half of them showing some possible connection, the other half irrelevant. When *tree* itself occurred as a stimulus word it was misread as *thee*. Of course it is possible that *tree* itself is really a complex word, but the evidence is doubtful. An instance of the latter sort is the perseveration of *hope* in the same observer. A thread of meaning connects the words to which *hope* was responded, although *hope* itself is not an appropriate response to any of them. This observer always gave logical responses except in cases of perseveration, that is, an illogical response was sure to be repeated. In determining complexes in this case perseverated words were the starting point, but no evidence was accepted unless there was more than one complex sign to each reaction considered. Some of the complexes unearthed in this way were the "travel" complex (probably a secondary complex, but this point cannot be established by the data at hand), the "discontent" complex, if we may call it so, for want of a better word—a complex revealed by the perseveration of *hope* and *full*, suggesting that hopes of better things and of wish-fulfillment were entertained, and the sex complex, indicated by several different groups of words. These will be discussed more fully under the head of the Freudian bearing of the experiment. The interpretation given will doubtless look far-fetched unless details are furnished.

The most interesting complexes, if not the most valuable for scientific purposes, are those that are distinctly individual and that give an insight into the character of the individual. While it is worth while to establish by experimental evidence that there are fundamental and universal ideas and emotions, it is no less important, for practical purposes, to discover the individual constellations. Some individual complexes are here cited as of interest and as presenting the definite results of the experiment.

Observer A: Love complex, exposed by 16 words, 33 complex signs, such as prolonged time, premature reaction or short time, embarrass-

ment, laughter, confusion of thought, unsuccessful effort to inhibit, significant response, blankness of mind, surrogate response, irrelevant response, misreading, inability to read. Also "The Lie" complex, exposed by 2 words, with 6 complex signs, such as prolonged time, blankness of mind, inhibition, unusual association, going back to childhood.

Observer B: "Dancing" complex exposed by 6, and possibly 15 words, and 15 complex signs, prolonged time, emotional excitement, significant associate. Also "Reciprocity," or "Twoness," exposed by 9 words and 16 signs, as prolonged time, perseverative idea of two people, emotion, significant association, post-critical response, frank consciousness of the complex.

Observer C: "Garden" complex, exposed by 8 words and 23 signs, as clang associations, redundant response, prolonged time, mixed emotion. (This is a puzzling one. It might be symbolic.) "Friendship" complex, exposed by 4 words and 12 signs, as prolonged time, clang association, irrelevant response, blankness of mind, evidence of repressed emotion.

Observer D: "Travel" complex exposed by 4 words and 12 signs, as perseveration, heterogeneity, redundant response, premature reaction, blankness of mind, automatic response, frank consciousness of complex. Also a "Hope" complex, exposed by 6 words, and 22 signs, as perseveration, prolonged time, misreading, automatic reaction, heterogeneity, irrelevance, some emotion conscious, more unconscious.

Observer E: "Marriage" complex, combined with "Love," exposed by 15 words and 32 signs, such as prolonged time, blankness of mind, confusion, significant association, failure to associate, feeling of being "in a trap," repressions, emotion, acknowledgment of complex. Also a complex connecting with the word "lake," real meaning unknown to experimenter. This was exposed by 5 words and 11 signs, much the same as the "Marriage" and "Love" complex signs.

Observer F: "Death" complex, with 5 words and 12 signs, among which were premature reaction, intense, painful, emotion, blankness, false reproduction, failure to react, failure to associate. A "Love" complex, exposed by 6 words and 13 signs, such as prolonged time, confusion, embarrassment, laughter, clang association, quotation, significant association, failure to react.

Observer G: "Dress" complex, with 6 words and 13 signs, among which were prolonged time, unusual and significant association, surprise, pleasurable emotion, blankness. Also a marked *"Welt Schmerz"* complex touched by 16 words and shown by 54 signs, chief of which was a recurring visual image of a mass of people, accompanied by prolonged time, failure to associate, great emotion, significant association.

Observer H: The "Motherhood" complex, exposed by 6 words and 12 signs, as prolonged time, inhibitions, conflict of associations, strong emotion, redundant and significant response. And also a "Manhating" complex exposed by 6 words and 22 signs, among which were prolonged time, significant response, irrelevant response, blankness, emotion, sense of hurry, failure to associate. (This observer is abnormal.)

V. The next, and last, question to be taken up is that of the bearing of this experiment on the Freudian doctrine. Is there any evidence presented by these results in support of the "complex theory" of Freud? This theory is, in substance, as follows:

1. The unconscious must be accepted as the general basis of psychic life. Experiences are not forgotten, or lost, they are repressed into the unconscious, where they remain active and dynamic. Everything conscious has its preliminary step in the unconscious. Our views, thoughts, and ideals, are all tinged, nay, formed, by these unconscious activities. These find their way out into the conscious life in indirect and hidden ways. Many otherwise unaccountable actions, associations, fancies, errors of apprehension, etc., are explainable as expressions of the repressed wishes, or "complexes" (4).

2. All effectual unconscious complexes are sexual, in Freud's broad sense of the word sexual. However broadened the complex may be to include affections, ambitions, fears, of every sort, there is a sexual component present. The sex instinct is therefore the fundamental instinct. All desires, wishes, and hopes are *derived from sexual desire* (6).

3. The unconscious thoughts, the complexes, all ambitions, wishes, and fears, etc., have their rise in infantile sexual experiences and thoughts. The memory of these is repressed into the unconscious, but the *complex,* i. e., the group of emotionally toned ideas, expressing an unfulfilled wish, remains active, conditioning the conscious processes. Thus is the child father to the man (6).

It is unnecessary here to go into Freud's applications of these principles, since all that we are concerned with is the question whether or not the association method used by Freud himself in exposing complexes, will, when applied by an impartial experimenter to normal subjects, yield evidence in support of these principles. What is their bearing upon the association experiment? Obviously, from data gathered in this experiment, *something* that is unconscious does play a rôle in determining the association of ideas, unless the association is a chance juxtaposition, and psychology has rejected the latter view. There is evidence also that this unconscious is active and dynamic. The complicated train of ideas sometimes recalled to consciousness afterward shows how intricate was the association that came out as an automatic response, often to the surprise of the subject. Associations are sometimes tinged by an emotional tone which the subject is at loss to account for. Also there are physiological manifestations of emotion, apparent to the experimenter without the aid of special testing instruments, manifestations such as quickened breathing, flushing, dilated pupil, fluttering of the hands,—of which the subject is unconscious. This is analogous to the emotion sometimes called forth by automatic

writing. These facts, brought out by experiment, lend support to the theory of the dynamic nature of the unconscious, and of its reality as a potent factor in conscious activity. The given associate reveals a *complex*—a group of emotionally toned ideas—at times, of the existence of which the patient is unaware, and he is convinced of its presence only by cumulative evidence. In this experiment there was little opportunity, and it formed no part of the purpose, to acquaint the observer with his own complexes but there was evidence that the observer was unaware of some of his complexes. This evidence was found in the introspection and especially in that part of the testimony elicited by the questions of the experimenter. The observer was sometimes aware of the emotion aroused without being able to explain it. When his associations were brought together and compared the complex stood out plainly, yet the observer sincerely denied its existence. Complexes, in the broad sense in which we have taken the term, are not necessarily painful and not necessarily repressed. An example of a complex that was both painful and repressed was the *death* complex of the neurotic subject. In a more normal subject an example is found in the horror connected with *prison* and in the *friendship* complex of another, who always associated the word *penmanship* (it was tried three times) and who could get no thought of the meaning of the word *friendship,* nor any definite thought except a reference to a friend who was absent. There was no conscious affective tone to this experience, but there was delayed reaction and an unusual absence of thought content. The complex that is fully conscious, and pleasant, is instanced by the *dancing* or *motion complex* of one observer. This sort too may present indirect evidence for Freud's first thesis, but it is to the other sort that we must look for direct support. The complex that is so far repressed that the subject is seldom or never aware of its existence is best explained by the theory that Freud advances.

The second thesis, that all the unconscious complexes have a sexual connotation, receives only a partial and inconclusive support. We can say that there are sexual complexes exposed in every observer—the marriage complex is sexual. We can say that some complexes the main objective of which does not seem to be sexual have also a sexual factor. But this does not amount to saying that *all* complexes are sexual, and all important motives to behavior are therefore sexual, even in the broad sense. This experiment could not be sufficiently wide in scope to establish this point, but if such data as could

be obtained were in its favor the fact would be worth noting. A complex traced through the perseveration of *tree* as a response, when tree seemed to express a state of mixed but predominantly pleasurable feeling, in which love of natural beauty was involved, was found to have a sexual component when the seemingly trivial association *fruit-tree* came up. The observer here acknowledged the presence of the sexual complex, otherwise the experimenter would not have been able to detect it. She could have known only that there was a complex of some sort. An observer less frank or less practised in introspection would not have given the information.

The *hope* complex of one observer seemed to be a complex of discontent with the present state of things in general, and the perseverated response voiced the unspoken wish. If one were a thorough-going Freudian one would say that the words to which hope was responded are evidence of a sexual, or Freudian, complex. They are friendship, master, pity, wealth, sin, victory. *Sin* brought a second associate also, in *pain*. But as we cannot proceed on the Freudian assumption we cannot regard these words as giving evidence. The words to which *me* was given as an associate are more suggestive. They are tree (misread as *thee*), dear, kiss, abuse, mate. Indeed, all the complexes shown by this particular observer *could* have a sexual connotation (including the marked travel complex), but there are only vague and inconclusive indications in the associations themselves. It would be necessary to assume the Freudian symbolisms and principles of interpretation in order to see in them incontrovertible proofs of sexual complex. The leaning of the experimenter toward sexual interpretations in this case comes from observations of behavior and of trends of thought, things noted in relationships remote from the experiment, from dreams told by the observer, and other such considerations that have no right to enter into the interpretation of the experimental data. And even if this observer were found to have only sexual complexes (again in a broad sense) it would not prove the theory. There is no doubt that *some* of the subjects examined by the Freudian school fully justify the theory but it cannot be made to apply universally from these few cases. In this experiment, as stated before, all observers give evidence of the presence of at least one sexual complex, in some form, but there is no evidence that the sexual complex is the dominant one, or that every complex has, hidden away in it somewhere, a sexual factor. In the table of complexes given, which did not represent *all* the complexes found, a number of sexual complexes

are named. All are susceptible of sexual interpretation if once we admit Freud's principle. But that is just what we cannot do until we have unmistakeable evidence, and we fear that we are not likely to get it by this method.

To the third thesis of Freud's theory the experiment gives no answer. Observers were asked to call attention to any association that they recognized as persisting from childhood. This was seldom done. An infantile root of the association was occasionally uncovered by the questioning of the experimenter but such cases are not in sufficient numbers to be significant. As was shown in the comparison of the normal and the abnormal types, references to childhood experiences are more frequent in the latter than in the former, and the infantile memories seem to play a not unimportant rôle in the complexes of the latter. But the point especially to be decided is that infantile experience plays an extremely important part in the complexes, or constellations, of normal, healthy, men and women. It is a point that an experiment conducted in the manner that this one was can never, so it appears to the writer, determine. Freud's method of uncontrolled "Free association" may lead the subject back to early experiences, helped out by skillful questioning and suggestion. But the word-association used here cannot possibly reach to the deep substratum of the unconscious where these infantile elements lie buried when life is normal and healthy. It is only in cases of mental mal-development that they persist near enough to the surface to be reached easily.

The association experiment, by the word-association method, can hardly be a valid test for the Freudian theories in their entirety. There are many points on which it is silent. The symbolic interpretations of Freud, veiling sexual meanings, may or may not be legitimate. But as these symbolic meanings do not penetrate to the consciousness of the subject without outside suggestion in any case, we cannot expect to find any conclusive evidence for them. Words that might be symbolic—there are many such in the list—are sometimes responded to in a way that suggests the presence of a complex, but without an illegitimate amount of guidance from the experimenter they cannot be made to take on a symbolic significance. The association experiment can probe the unconscious to a certain extent, but it cannot probe to every possible depth. We are not justified in saying that there is nothing more than what has been revealed by experiments similar to this one, neither are we justified in assuming as the truth anything that has not been proved experimentally. The experiment here

treated leaves much of the Freudian question open, or it leaves it, to speak more modestly, just where it found it.

VI. This experiment has, when results are brought together, confirmed some facts, brought out by other investigators and has brought up some new data on certain minor points. It has corroborated the statement already accepted by most psychologists, that by the association method mental character may be studied. Many different factors of the reaction, both quantitative and qualitative, enter into the character-indications. It is found possible to establish definite reaction types, with correlation of certain features of the reaction.

In the study of reaction consciousness certain definite features in the reaction come to stand out as 'complex signs.' They are quantitative, qualitative, and physiological. The presence of two or more such signs in any reaction is likely to indicate a complex. As it is seldom that a complex is acknowledged by the observer these signs assume great importance in the exposure of the complex. Certain complexes are in this manner indicated as of common and, it might be inferred, of universal occurrence. These may have innumerable individual variations but there is a fundamental instinct at the base of them. Certain subjects of perennial interest arouse interest and feeling when introduced into the association experiment. They are not *shocking* subjects—the introduction of such would be a gross abuse of the experiment as a means of exposing complexes—but are words in common use and words not evoking extraordinary behavior in every day life. The detached presentment of each word in the association experiment enhances the value of the word, so that it represents a situation to the subject, and he responds accordingly. A part of his behavior to the situation is unconscious, and it is this unconscious part that is most significant. Unconscious mental processes and partly conscious mental processes are much in evidence and the method furnishes a reliable means of "tapping the subconscious" But evidence for the Freudian theory of the unconscious, beyond the first general thesis, is lacking.

If this thesis has anything new to offer it is a new point of view rather than new facts. Hitherto the work upon the complex has been prosecuted from the diagnostic point of view, with the purpose of seeking the individual complex, while the common complexes were disregarded, being taken for granted. In this experiment the principal interest has been in finding out just how these common complexes are manifested in different observers, and how far the association method is of

service in uncovering them. A result of the experiment that at least deserves mention, then, is the actual demonstration of the occurrence of certain common complexes in all observers used in the experiment—complexes that manifested themselves in various ways but had certain unmistakeable common characteristics, nevertheless, that could not be concealed by the differences in type.

Of many minor products of the experiment it is impossible to speak, nor has there been opportunity to work out fully all the points suggested by the data. Such points offer numerous incentives to further study, which is their main contribution. The phenomenon of conflicting tendencies in association offers such an incentive. The trend of thought that holds the foreground is very likely to fail of expression, while the association that emerges, either as a word or image, is the result of a trend that was not realized as present until after its culmination. Conflicting tendencies often lead to an inhibition of reaction when no complex is present. The so-called clang associations and rhyming associations are interesting also, as studies. They seem often to indicate a state of resistance to the whole situation, or a *lazy* way of avoiding the effort to associate ideas. They occur oftenest when the observer is bored or fatigued, although they also are sometimes used to conceal complexes. Not unrelated to this phenomenon is perseveration, which, in the results treated here, usually indicated *not* poverty of ideas, but affective mental states. An egocentric attitude usually underlies the perseverative tendency.

A point that there has not been time to work out is that of the general curve in the reaction time of each observer. It has been noted that the time seems to vary most, going to extremes, just after a critical reaction. A question that one would like to see conclusively settled is that of the exact relation of the reaction time to the complex. By the earliest investigators it was thought that a complex always caused a lengthening of the time, but data has since been brought forward to discountenance this view, and, in the opinion of the writer, finally to disprove its correctness.

More detailed study of the data at hand would doubtless bring up more questions, and would perhaps answer a few of them. In conclusion it may be said that this association experiment has proved very fruitful as a means of studying individual psychology, and that it appears to indicate one of the best methods available for the study of a large group of very significant mental processes.

List of words used in experiment:

head; water; green; dream; plant; coat; cigar; kitchen; cold; rose; girl; death; year; wages; window; friendship; master; seed; garden; key; ship; dance; railroad; cave; fight; knife; snake; salt; coffin; mountain; yellow; pity; pain; tree; sky; wealth; sin; new; tunnel; whip; stairway; steamer; wagon; horse; ladder; automobile; blue; voyage; needle; anger; ink; trunk; prison; sickness; lake; village; red; custom; prayer; money; foolish; pamphlet; contempt; finger; expense; bird; fall; book; injustice; black; question; church; organ; captain; victory; bet; frog; separation; hunger; white; child; care; pencil; grief; plum; blockade; suspense; goal; game; marriage; dear; glass; quarrel; fur; size; carrot; paint; part; note; dress; veil; cherry; ace; fruit; age; flower; punishment; box; savage; family; soap; cow; friend; luck; lie; deportment; path; sister; fear; stork; falsehood; diamond; beauty; ring; indifference; costume; lady; knight; anxiety; door; kiss; purity; choice; hay; bride; contentment; ridicule; sleep; month; delight; nest; milk; meat; doll; dwarf; masquerade; woman; abuse; mouth; mate.

Graded word list, showing which words were effectual as complex indicators. The first eight words were significantly reacted to by eight observers, the next eight by seven and so on down:

8: marriage; dream; sin; death; coffin; choice; bride; ridicule.
7: friendship; child; blockade; quarrel; seed; contempt; expense; size.
6: water; coat; girl; flower; anxiety; abuse.
5: delight; prison; pity; suspense; dwarf; kiss; horse; dance; song; game.
4: year; wealth; anger; finger; separation; friend; tunnel; whip; bet; victory; mate; pride; punishment; prayer; diamond; ship; door; dear; ladder.
3: mountain; ring; sleep; stairway; captain; luck; costume; beauty; master; veil; sky; injustice; bright; dwarf; cave.
2: plant; book; ace; box; next; bird; goal; free; cold; fear; wages; knight; family; automobile; purity; money; fall; question; care; lie; trunk; pain; knife; fear; falsehood; ring.
1: month; lady; ship; cigar; master; key; village; lake; sickness; railroad; bet; plum; glass; fur; fruit; age.

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BOOK NOTES

Bodily changes in pain, hunger, fear and rage; an account of recent researches into the function of emotional excitement. By WALTER B. CANNON. New York, Appleton, 1915. 311 p.

In this long desired volume the author sums up the results of his own experiments and gives us a general presentation of the subject. In successive chapters he deals with the effect of the emotions on digestion, the general organization of the visceral nerves concerned in emotions, methods of demonstrating adrenal secretion and its nervous control, adrenal secretion in strong emotions and pain, the increase of blood sugar in pain and great emotion, improved contraction of fatigued muscle after splanchnic stimulation of the adrenal gland, the effects on contraction of fatigued muscle of varying the arterial blood pressure, the specific rôle of adrenin in counteracting the effects of fatigue, the hastening of the coagulation of blood by adrenin, the hastening of coagulation of blood in pain and great emotion, the utility of the bodily changes in pain and great emotion, the energizing influence of emotional excitement, the nature of hunger, the interrelations of emotions, and alternative satisfactions for the fighting emotions.

An introduction to neurology. By C. JUDSON HERRICK. Philadelphia, W. B. Saunders Co., 1915. 355 p.

This is evidently a very welcome and much needed book. It is intended to be and is an admirable "Open Sesame" for the beginner and an excellent summary of what is known to date. The book is illustrated by 137 diagrams, contains an excellent index and glossary and in its successive chapters treats the following topics: the nervous functions, the neuron, reflex circuits, receptors and effectors, general physiology of the nervous system, general anatomy and subdivision of the nervous system, spinal cord and its nerves, the medulla oblongata and cerebellum, cerebrum, general somatic systems of conduction paths, vestibular apparatus and cerebellum, auditory apparatus, visual apparatus, olfactory apparatus, sympathetic nervous system, visceral and gustatory apparatus, pain and pleasure, structure of the cerebral cortex, functions of the cerebral cortex, evolution and significance of the cerebral cortex.

The problem of knowledge. By DOUGLAS CLYDE MACINTOSH. New York, Macmillan, 1915. 503 p.

This impressive volume falls into two parts. The first and longest treats of the problem of immediate knowledge, and under this falls that of acquaintance (or epistemology proper), where the author gives a critique of dualism, idealism, rationalism and finally a constructive statement, which is critical monism. Then follow problems of the ways and means of knowing, or the morphology of knowledge and genetic logic, and the genesis of the apriori. Part second discusses the problem of mediate knowledge, first that of truth or logical theory, criticising intellectualism and anti-intellectualism, and defending criti-

cal monism in logical theory, and second, the problem of proof (or methodology) which deals with scientific method. The reader will thank the author for an analytical table of contents that precedes the volume itself.

The natural history of the state. By HENRY JONES FORD. Princeton, Princeton University Press, 1915. 188 p.

Princeton University has for decades had an intense consciousness of Darwinism. This was most acute, perhaps, in the time of President McCosh, and seems to work in an ambivalent way, so that those who now believe in evolution are a little prone to magnify its influence and to stretch analogies to conform to it. This seems to us the case in this book. Sociology and economics have passed beyond what the author calls the Huxleyan position, and the genesis of language is far too shaky a foundation to build anything on. Darwin and Romanes are antiquated authorities now on animal psychology, and the author's summaries, biological, psychological, linguistic, and anthropological, seem to the writer of this note distinctly behind the times.

School hygiene. By LEO BURGERSTEIN. Translated by Beatrice L. Stevenson and Anna L. Von Der Osten. New York, Frederick A. Stokes Co. (c. 1915). 188 p.

The author of this manual is one of the chief leaders in school hygiene and it is a godsend to all interested in the subject to have his views presented in this brief, concise form, with copious illustrations, so that it is no wonder that although the first edition appeared in 1912, we have before us already a third edition. Under The Schoolhouse are treated General Planning and Erection, Lighting, Ventilation and Heating, Classroom and Equipment, Grounds, etc.; under Hygiene of Instruction, Number of Pupils and Curriculum, Hygiene of Different Topics, Homework, Examinations, Boarding Schools. Under Instruction in Hygiene we have School Diseases and Medical Inspection, and Hygiene of the Teaching Profession.

Out of work; a study of unemployment. By FRANCES A. KELLOR. New York, G. P. Putnam's Sons, 1915. 569 p.

This work was prompted by the extraordinary degree of unemployment in the winter of 1914-15. The chapters discuss unemployment among women, children, the labor market, relations of immigration, how America markets its labor, labor agencies, domestic service and the intelligence office, marketing skilled labor, philanthropic and civic experiments, public agencies, government regulations, relief of unemployment, insurance against it, program for America. Besides this the work contains useful appendices on national relief, public work, municipal plans, church programs, insurance, etc.

Character and temperament. By JOSEPH JASTROW. New York, Appleton, 1915. 596 p.

This appears to be the first volume of a series by the author entitled "The Conduct of Mind Series," designed to provide readily intelligible surveys of selected aspects of the study of mind and of its applications. The nine chapters of this work are as follows: The Scientific Approach, The Sensibilities, The Emotions and Conduct, The Higher Stages of Psychic Control, Temperament and Individual Differences, Abnormal Tendencies of Mind, The Psychology of Group-Traits, Character and the Environment, and The Qualities of Men.

The function of social taboo in education. By IVA L. PETERS. 84 p.

This pamphlet is apparently a thesis, and perhaps even is incomplete, but as it stands it is altogether the most interesting study of girls in the teens known to the writer. The author interprets taboo in a very broad sense and has collected many compositions, compiled many data from questionnaires, and does present a most vivid picture of what girls cannot do and the restrictions, prohibitions and even the positive injunctions that hedge in their lives at home, in school, and even in class. Happily, however, taboo is now passing.

The "conscious cross-section"; a realistic psychology. By ROBERT CHENAULT GIVLER. Seattle, Dept. of Printing, University of Washington, 1915. 412 p.

This work consists of five chapters, as follows: terminology, psychological analysis, the sensitive and perceptive organs, the emotional complex, matters and minds. "Either logic or flapdoodle. This is the thesis defended in this book with regard to the analysis of mind." The two ever-recurring items are the special form of analysis used, and the continual reference to deep-seated errors in popular psychology. The author is chiefly indebted to the "Concept of Consciousness" by Professor Holt of Harvard University.

Backward children. By ARTHUR HOLMES. Indianapolis, Bobbs-Merrill (c. 1915). 247 p.

This is an inductive study of backward children presenting in a series of concrete illustrations the studies of cases to exemplify principles and methods of diagnosis, treating and training. It describes measuring rods for children, varieties of backward children, typical retardation due to physical defects, minds in straight jackets, bad and backward, retardation due to environment, the backward child in the home, clinical diagnosis, the teacher's diagnosis, the teacher and equipment for a special class.

What may I hope? An inquiry into the sources and reasonableness of the hopes of humanity, especially the social and religious. By GEORGE TRUMBULL LADD. New York, Longmans, Green, 1915. 310 p.

This is the fourth in a series of volumes of which the first three have previously appeared, "What Can I Know?" "What Ought I to Do?" and "What Should I Believe?" The chief themes are the nature and sources of hope, rights and limitations of hoping, the assurance of hope, the practical uses of hoping, concerning hopes, scientific, political and social, the hope of moral perfection, the hope of immortality, and the hope of a divine kingdom.

Recognition: a logical and experimental study. By ROBERTS BISHOP OWEN. Psychological Monographs, Vol. XX, No. 2, October, 1915. 154 p.

The author gives first an historical résumé of theories, then a discussion of logical aspects of the problem and consequent assumptions relative to experimental technique. Then come the experiments, as to the recognized content being perceptually present, the time of judgment, voluntary recall and the prompting method, opportunity for intellectual analysis limited, the effect of congruity with context, memory and imagination.

Lehrbuch der experimentellen Psychologie für höhere Schulen und zum Selbstunterricht. Von Joseph Fröbes. Erster Band, Erste Abteilung. Freiburg i. B., Herdersche Verlagshandlung, 1915. 198 p.

After discussing the goal and the way of empirical psychology, the first section treats sensation in general; the second, the single sensations and other elements, sight, hearing, smell, taste, skin sensations, kinaesthetic, aesthetic and organic sensations, and the simple sense feelings.

The school and the immigrant. Edited by Albert Shiels. New York, Department of Education, Division of Reference and Research, Publication No. 11, 1915. 96 p.

This is a series of practical articles by six writers, treating the problem as a whole, methods of teaching English to foreigners, instruction in civics, the occupations of foreign workers, development of social and recreational life, and naturalization.

Nietzsche's moral aim. By William Mackintire Salter. (Reprinted from the International Journal of Ethics, January and April, 1915, pp. 226-403.)

These two articles constitute an admirable epitome of and introduction to Nietzsche, with adequate notes and bibliography. Of the many interpretations of Nietzsche this certainly is one of the most sagacious.

The thinking universe; reason as applied to the manifestations of the infinite. By Edmund E. Sheppard. Los Angeles, Calif., The Authors' Co. (c. 1915). 347 p.

"The aim of this work is to make comprehensible the Grandeur of the Immobile, Intangible Infinite, reposing Majestically in its Eternal, Unchanging Stillness, in Everything, as Everything, propelling Everything."

Subject and object. By Johnston Estep Walter. West Newton, Pa., Johnston & Penny, 1915. 184 p.

This work consists of four chapters, discussing respectively the subject or soul, subject and object in their relation, the nature and our perception of matter, and truth.

Life and work of Pestalozzi. By J. A. Green. Baltimore, Warwick & York, n. d. 393 p.

The teaching of drawing; its aims and methods. By S. Polak and H. C. Quilter. Second impression. Baltimore, Warwick & York, n. d. 168 p.

The Institution Quarterly. Vol. VI, No. 1. Springfield, Illinois, March 31, 1915. Edited by A. L. Bowen. 236 p.

International clinic week at the New York Polyclinic Medical School and Hospital, during the International Surgical Congress, April, 1914. By Alfred C. Jordan and others. New York. 103 p.

Aristotle on his predecessors; being the first book of his Metaphysics. Translated by A. E. TAYLOR. Chicago, Open Court Pub. Co., 1910. 159 p.

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